IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CELLCO PARTNERSHIP D/B/A VERIZON WIRELESS,
T-MOBILE USA, INC., AT&T SERVICES, INC.,
NOKIA OF AMERICA, CORP., ERICSSON INC., AND GOOGLE LLC
Petitioners,

v.

KT CORPORATION (PATENT OWNER) AND PEGASUS WIRELESS
INNOVATION LLC (EXCLUSIVE LICENSEE)
Patent Owner.

U.S. Patent No. 11,540,272
Title: METHOD AND DEVICE FOR ALLOCATING DATA CHANNEL
RESOURCE FOR NEXT-GENERATION WIRELESS ACCESS NETWORK

Inter Partes Review No.: IPR2025-00137

DECLARATION OF TOMMASO MELODIA, Ph.D., UNDER 37 C.F.R. § 1.68 IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 11,540,272

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1. A base station, comprising: a transceiver; a receiver; and a controller which controls the transceiver and receiver thereby performing operations including:.....80

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[1.2] wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and; 95

[1.3] wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and; 100

[1.4] transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string,.....101

[1.5] wherein the bit string in the field relates to a row index of an allocation table, and 101

[1.6] wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot. 101

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a) Claim 1 120

[1.0] A base station, comprising: a transceiver; a receiver; and a controller which controls the transceiver and receiver thereby performing operations including: 121

[1.1] transmitting, to a wireless device, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource, wherein the time-domain resource includes

at least one or more orthogonal frequency-division multiplexing (OFDM) symbols, ...124

[1.2] wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and; 134

[1.3] wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and; 137

[1.4] transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string,.....138

[1.5] wherein the bit string in the field relates to a row index of an allocation table, and. 144

[1.6] wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot......147

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device, downlink data via the PDSCH; and receiving, from the wireless device, uplink data via the PUSCH. 160

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vi. The base station [wireless device / method] of claim 1 [8 / 15], wherein the base station supports different numerologies which are defined by a subcarrier spacing (SCS).....165

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Petitioner's Exhibit List

Exhibit #	***Description***
1001	U.S. Patent No. 11,540,272 ("the '272 Patent")
1002	Select portions of prosecution history of the '272 Patent ("File History")
1003	Declaration of Petitioners' Expert ("Melodia Declaration")
1004	U.S. Pat. Pub. No. 2018/0376497 ("You")
1005	KR2016/008093 ("You PCT") filed on July 25, 2016 (WO 2017/018761)
1006	Certified Translation of EX-1005 (WO 2017/018761)
1007	U.S. Pat. Pub. No. 2020/0187169 ("Gao")
1008	CN201610849716.8 ("Gao Priority Application")
1009	Certified Translation of EX-1008
1010	3GPP Specification 36.213, Release 13.1.0 (published March 2016)
1011	3GPP Specification 36.212, Release 13.1.0 (published March 2016)
1012	Declaration of Craig Bishop ("Bishop Declaration")
1013	List of related patents
1014	Plaintiff Pegasus Wireless Innovations LLC's Disclosure of Asserted Claims and Infringement Contentions, Verizon Case.
1015	'272 Patent Priority Application (October 31, 2016)
1016	Certified Translation Of October 31, 2016 Priority Application For '272 Patent
1017	RAN 84-BIS list of attendees (including inventor)
1018	RAN 86 list of attendees (including inventor)
1019	RAN 86-BIS list of attendees (including inventor)
1020	R1-1610129
1021	RAN1#86-BIS Meeting Draft Minutes (dated October 20, 2016).
1022	*Pegasus Wireless v. Cellco Partnership d/b/a Verizon Wireless*, Case 2:23-cv-00640-JRG (EDTX), Docket Control Order

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Exhibit #	***Description***
1023	Websters definition of "table" (https://www.merriam-webster.com/dictionary/table)
1024	Britannica definition of "table" (https://www.britannica.com/dictionary/table)
1025	KT Corporation Motion For Protective Order From Questioning Beyond The Scope Of Jurisdictional Discovery (Redacted), Dkt. No. 172, case 2:23-cv-00640.
1026	Excerpts from Prosecution History Of Application 16/346,108 (parent application to '272 patent)
1027	Order Granting Protective Order, case 2:23-cv-00640-JRG Document 178 (12/12/2024)

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I, Tommaso Melodia, Ph.D. hereby declare as follows:

I. INTRODUCTION

1. I have been retained as an expert witness on behalf of Petitioners for the above-captioned Petition for *Inter Partes* Review ("IPR") of claims 1-20 of U.S. Patent No. 11,540,272 ("the '272 patent") (the Challenged Claims). I am being compensated for my time in connection with this IPR at my standard consulting rate of $500 per hour. My compensation is in no way dependent on the outcome of this matter.
2. I have been asked to provide my opinions regarding whether the Challenged Claims are unpatentable as obvious. In preparing this declaration, I have reviewed the '272 patent, the file history of the '272 patent, and numerous prior art references from the time of the alleged invention.
3. In forming the opinions expressed in this declaration, I relied upon my education and experience in the relevant field of the art, and have considered the viewpoint of a person having ordinary skill in the relevant art, as of January 2009.
4. I understand that '272 claims priority through several applications with the earliest filed on October 31, 2016. For purposes of my analysis below, I

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assume the October 31, 2016 date as the Priority Date of the '272 patent and the Challenged Claims because the prior art herein predates October 31, 2016. However, my analysis does not concede that the Challenged Claims are entitled to the October 31, 2016.

5. My opinions directed to the unpatentability of the challenged claims are based, at least in part, on the following prior art publications:

Reference	Date of Public Availability
U.S. Patent Publication No. 2020/0187169 ("Gao") (EX-1007)	Gao claims priority to CN201610849716.8 filed on September 23, 2016 through PCT No. PCT/CN2017/098522 filed August 22, 2017. Gao has substantively the same content as CN201610849716.8 which is in Exhibit EX-1008 and the certified translation is in EX-1009). Gao is therefore prior art under the post-AIA provisions of 35 U.S.C. §102. Gao is attached to the Petition as Exhibit EX-1007.

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U.S. Patent 2018/0376497 ("You") (EX-1004)	published on December 27, 2018 from application No. 15/747,028 which is the U.S. National Stage of PCT KR2016/008093 filed on July 25, 2016 (WO 2017/018761). You has substantively the same content as KR2016/008093 attached as EX-1005 and shown in EX-1006 which is a certified translation. You is therefore prior art under the post-AIA provisions of 35 U.S.C. §102. You is attached as Exhibit 1004 to the IPR.
3GPP Standard TS 36.213 v13.1.0 (EX-1010) ("3GPP36-213")	3GPP Standard TS 36.213 v13.1.0 (EX-1010) ("3GPP36-213") published and was publicly available no later than March 2016. 3GPP36-213 is therefore prior art under the post-AIA provisions of 35 U.S.C. §102. 3GPP36-213 is attached as Exhibit 1010 to the IPR.

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3GPP Standard TS 36.212 v13.1.0 (EX-1011) ("3GPP36-212")	3GPP Standard TS 36.212 v13.1.0 (EX-1011) ("3GPP36-212") published and was publicly available no later than March 2016. 3GPP36-212 is therefore prior art under the post-AIA provisions of 35 U.S.C. §102. 3GPP36-212 is attached as Exhibit 1011 to the IPR.
R1-1610129 (EX-1020)	R1-1610129 (EX-1020) was published and publicly available no later than October 14, 2016. R1-1610129 is therefore prior art under the post-AIA provisions of 35 U.S.C. §102. R1-1610129 is attached as Exhibit 1020 to the IPR.

II. BACKGROUND AND QUALIFICATIONS

6. My background and expertise that qualify me as an expert in the technical issues in this case are as follows:

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7. As indicated on my *Curriculum Vitae* attached as **Exhibit A**, I received my Laurea Degree (integrated BS and MS Degree) in Telecommunications Engineering from the University of Rome, La Sapienza, in Italy, in 2001. Subsequently, I received a Doctorate in Information and Communication Engineering from the same university, and a Ph.D. in Electrical and Computer Engineering from the Georgia Institute of Technology in 2007.

8. After completing my Ph.D., I joined the University at Buffalo, The State University of New York as an Assistant Professor in the Department of Electrical Engineering. While at the University at Buffalo, I taught undergraduate and graduate courses in wireless communications and networks, and I conducted research in modeling, optimization, and experimental evaluation of wireless networked systems with sponsorship from the US National Science Foundation, the Air Force Research Laboratory, and the Office of Naval Research. I received the National Science Foundation CAREER Award and supervised the PhD theses of four students. In 2013, I was promoted to the rank of Associate Professor and granted tenure.

9. In 2014, I joined Northeastern University, as a tenured Associate Professor with the Department of Electrical and Computer Engineering. In 2018, I

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was promoted to the rank of Full Professor and granted the William L. Smith Chair Professorship.

10. At Northeastern, I have been the founding Director of the Institute for the Wireless Internet of Things, a leading research institute around smart and connected systems, with a focus on 5G and beyond-5G technologies and Open Radio Access Networks, which today includes an estimated 150+ researchers. I also lead the Open6G R&D Center within the Institute. Open6G is leading groundbreaking research and development in Open Radio Access Networks (Open RAN). My expertise encompasses the design, optimization, and security of wireless networked systems, with significant contributions to the development of Open RAN architectures and technologies. I have been leading multiple high-profile research projects funded by the National Science Foundation and other prestigious organizations. Notable projects include the development of advanced Open RAN systems like AutoRAN and DigiRAN, which push the boundaries of cellular system testing and digital twin technologies for network interoperability and security.

11. Since 2017, I have also overseen research as a Director of the National Science Foundation Platforms for Advanced Wireless Research (PAWR)

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Project Office, a $100M public-private partnership developing experimental testbeds for advanced wireless research throughout the United States.

12. In 2018, I was elevated to IEEE Fellow, and in 2023 I became an ACM Distinguished Member and in 2024 I was elected a Fellow of the National Academy of Inventors (NAI).

13. I have published extensively (over 300 peer-reviewed scholarly articles) in leading conferences and journals in the field of wireless communications and networking. I received several best paper awards at major conferences, including the Best Paper Award at IEEE Infocom 2022, the top IEEE conference in the field of computer networks. My articles have been cited 25,000+ times, with an h-index of 65, demonstrating the impact of the work in the academic community.

14. I am the Editor in Chief of Computer Networks, a co-founder of the 6G Symposium, and served as the Technical Program Committee Chair for IEEE Infocom, and General Chair for ACM MobiHoc, leading academic conferences in the field of wireless communications. I am the inventor for over 50 patents, of which 30+ have been granted.

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15. I serve on the board of the OpenAirInterface Software Alliance (OSA), a consortium including leading companies in the 5G space like Ericsson and Qualcomm. The OSA is developing an open-source implementation of 5G-and-beyond networks. I also serve on the executive board of the AI-RAN Alliance (as the only academic member) and on the research council of the ATIS NextG Alliance, an industry consortium shaping a research vision for 6G in North America.

16. My research on modeling, optimization, and experimental evaluation of wireless networked systems has been funded by many US government agencies, including the National Science Foundation, DARPA, the Office of Naval Research, the Office of the Undersecretary of Defense, the Department of Transportation, and the National Telecommunications and Information Administration. My research is also funded by a large industry consortium including industry leaders like Qualcomm, Interdigital, Dell Technologies, NVIDIA, Keysight, VIAVI, Raytheon, among others.

17. I am a frequent Keynote Speaker at leading International Conferences, including recently at the 6G Symposium, IEEE WF-IoT 2024, IEEE LANMAN 2023, IEEE WCNC 2024, among others. In 2023, I was selected

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as Hanscom Air Force Base Honorary Director for Information and Communication Technology.

18. [This paragraph left intentionally blank].

III. MATERIALS CONSIDERED FOR THIS DECLARATION

19. In addition to my general knowledge, education, and experience, I have considered all of the materials referenced in my declaration as well as the materials listed in **Exhibit B** in forming my opinions.

IV. SUMMARY OF OPINIONS

20. The prior art grounds identified below renders the Challenged Claims obvious.

21. In my analysis herein, I have considered the various disclosures (e.g., the '042 patent, the prior art, …) from the view of a person of ordinary skill in the art ("POSITA") at the time of the invention, which I have also referenced as the "priority date" herein.

22. The Challenges are set forth in detail below and summarized as follows:

Ground	Claims	Basis	Reference
1	1-20	§ 103	Gao, alone, or in view of You
2	1-20	§ 103	You, alone, or in view of Gao

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3	1-20	§ 103	Gao, alone, or in view of You, in further view of 3GPP36-213 and 3GPP36-212
4	1-20	§ 103	You, alone, or in view of Gao in further view of 3GPP36-213 and 3GPP36-212
5	1-20	§ 103	Grounds 1-4 in further view of R1-1610129

23. [This paragraph left intentionally blank].

V. THE '272 PATENT AND ITS PROSECUTION HISTORY

A. The '272 Patent.

24. According to the face of the '272 patent,

> This application is a continuation of U.S. application Ser. No. 16/346,108, filed on Apr. 29, 2019, which is a National Stage Patent Application of PCT International Patent Application No. PCT/KR2017/012105, filed on Oct. 30, 2017 under 35 U.S.C. § 371, which claims priorities to Korean Patent Application Nos. 10-2016-0143013, filed on Oct. 31, 2016 and 10-2017-0140898, filed on Oct. 27, 2017,

'272 Patent, 1:9-16. I reference the October 31, 2016 application herein as the "Priority Application."

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25. The '272 patent is generally directed to "a method for a base station to allocate a time interval resource to transceive a downlink data channel (PDSCH) or an uplink data channel (PUSCH). The method include allocating a time interval resource for each OFDM symbol on the basis of a slot or a mini-slot, transmitting, to a terminal, time interval resource configuration information including OFDM symbol allocation data for OFDM symbols used for data channel transception in the slot or the mini-slot, and transmitting, to the terminal, control information selecting one of the symbol allocation data included in the time interval resource configuration information." EX-1001, Abstract. The "Background Art" attempts to identify the problems that the '272 patent seeks to address in stating:

> Recently, the 3GPP has approved the "Study on New Radio Access Technology", which is a study item for research on next-generation/5G radio access technology. On the basis of the Study on New Radio Access Technology, Radio Access Network Working Group 1 (RAN WG1) has been discussing frame structures, channel coding and modulation, waveforms, multiple access methods, and the like for the new radio (NR). It is required to design the NR not only to provide an improved data transmission rate as compared with the long term evolution (LTE)/LTE-Advanced, but also to meet various requirements in detailed and specific usage scenarios.

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> In particular, an enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and ultra reliable and low latency communication (URLLC) are proposed as representative usage scenarios of the NR. In order to meet the requirements of the individual scenarios, it is required to design the NR to have flexible frame structures, compared with the LTE/LTE-Advanced.
>
> In the typical LTE/LTE-A system, the allocation of an uplink/downlink data resource has been performed on a resource block (RB) basis in the frequency axis and on a subframe basis in the time axis.
>
> Thus, in a downlink subframe, a UE receives downlink data through all OFDM symbols except for a control region for PDCCH transmission. In an uplink subframe, the UE transmits uplink data through all SC-FDMA symbols of the uplink subframe, or all SC-FDMA symbols except for the last symbol in case a SRS is configured.
>
> In this regard, in the NR, discussions have been conducted for allocating a time-domain resource as well as a frequency resource as a scheduling resource for an uplink/downlink data channel.

'272 Patent, 1:27-59.

26. The '272 patent proposes a method by which a base station can allocate resources for PUSCH / PDSCH on a more granular basis than the sub-frame allocation that was generally performed in LTE. The purpose of this more granular allocation, according to the '272 patent (as noted above) was to support new services that required lower latency – such as URLLC. The '272 patent acknowledges that the concept of more granular time allocation

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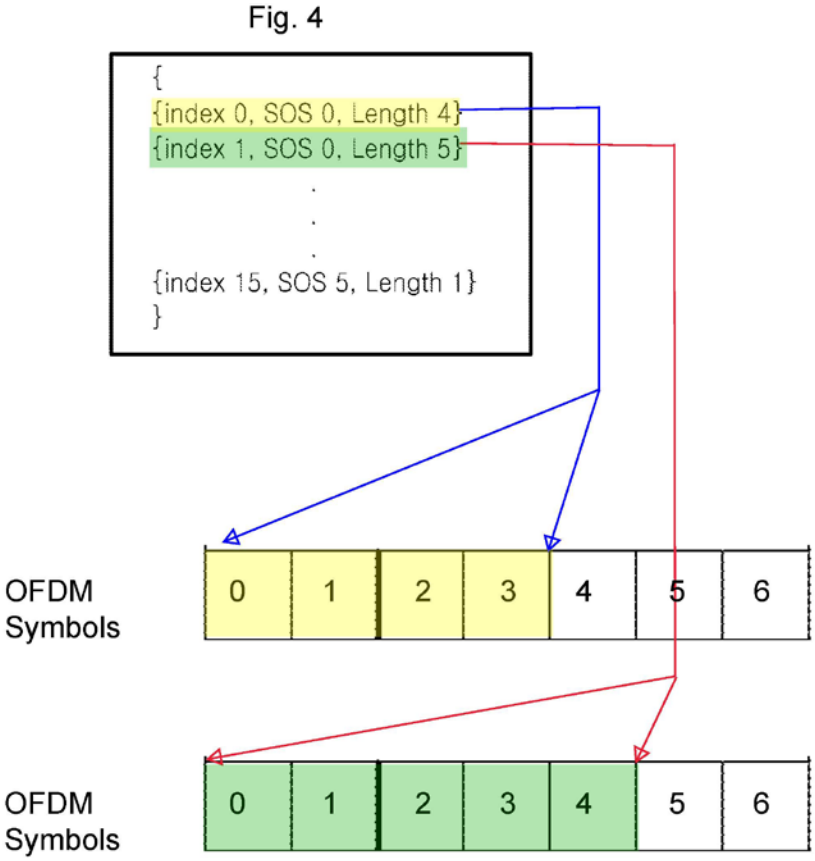
had been discussed in the 3GPP NR working groups prior to the filing of the Priority Application.

27. The '272 patent's Figures 4 and 5 depict exemplary tables that are not present in the Priority Application which relate to the table discussion below. EX-1001, 2:56-60. The Priority Application's Table 1 depicts a different "table." EX-1016, 0060-0063. Each table row reflects a different set / pattern of OFDM symbols (depicted at the annotated diagram's bottom portion added to Fig. 4).



28. EX-1001, Fig. 4 (annotated). The row with "index 0" allocates a region of symbols with a "SOS" ("starting OFDM symbol") of symbol 0 and a "length" of

4 symbols. The row with "index 1" reflects a different set / pattern of symbols in a region of symbols with a "SOS" of symbol 0 and a "length" of 5 symbols. This "allocation table" and its "row index" are recited in claim elements [1.5]-[1.6] discussed below in both Ground 1 and Ground 2.

29. In the '272 claims, bits in the downlink control information ("DCI")[1] specify an "index" in the table row used to specify OFDM symbols for transmission. This arrangement can be shown by using Figs. 4 and 5 together:

[1] DCI is transmitted in 4G and 5G systems (long before the '272 patent) by the BS to the UE to provide control information specifying how to interpret/decode the downlink data transmissions from the BS to the UE.

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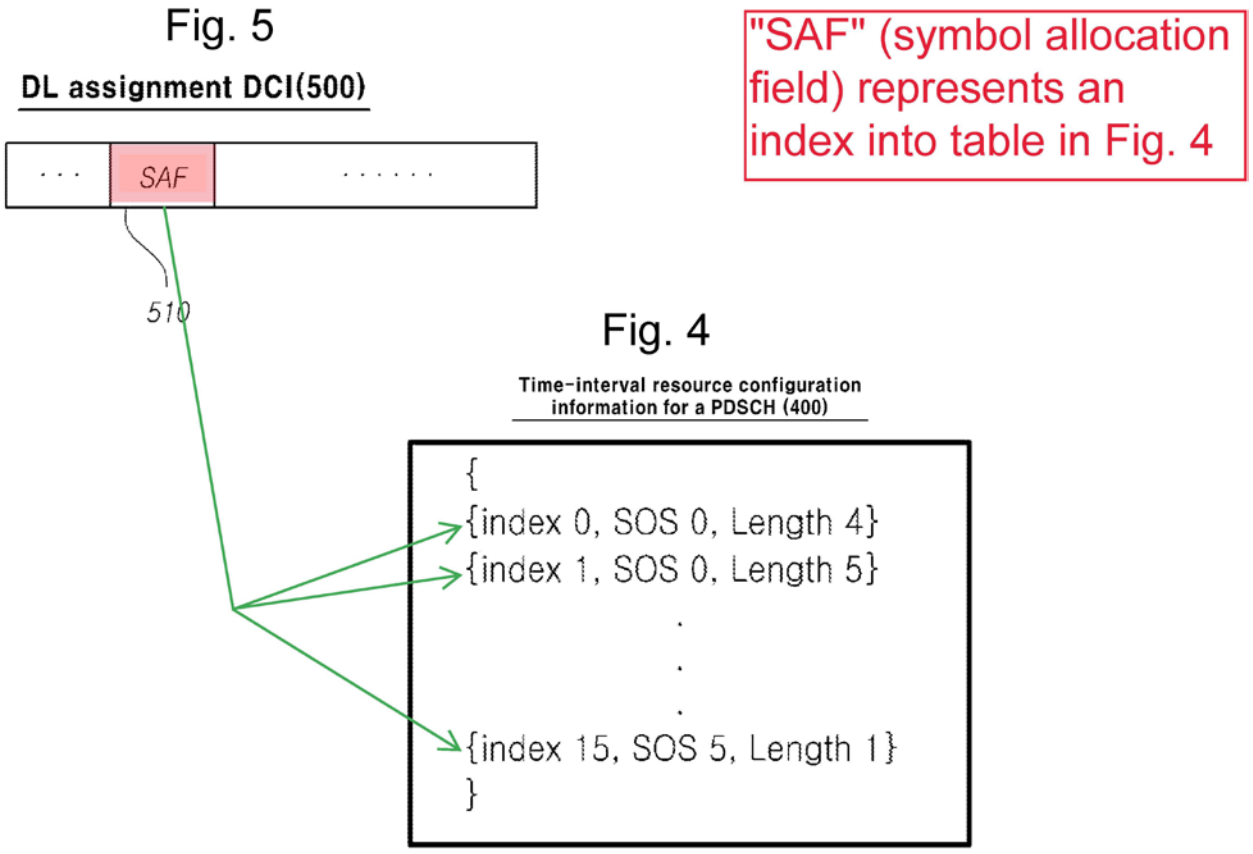

30. EX-1001, Figs. 4-5 (annotated). The "SAF" ("symbol allocation field") bits relate to an index to select the row in Figure 4 identifying a pattern of OFDM symbols for data transmissions between the BS and UE. EX-1001, 14:4-29; EX-1003, ¶¶XXX. These SAF bits are referenced in element [1.4] below.

31. As noted above, the '272 patent includes 20 claims which I have included below:

1. A base station, comprising:

a transceiver;

a receiver; and

a controller which controls the transceiver and receiver thereby performing operations including:

transmitting, to a wireless device, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource,

wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols,

wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and

wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and

transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string,

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wherein the bit string in the field relates to a row index of an allocation table, and

wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot.

2. The base station of claim 1, wherein the bit string is 3 bits in length.

3. The base station of claim 1, wherein the DCI further includes information on one or more allocations of a frequency-domain resource.

4. The base station of claim 1, wherein the base station supports a new radio access technology (NR).

5. The base station of claim 1, wherein the base station supports different numerologies which are defined by a subcarrier spacing (SCS).

6. The base station of claim 1, wherein the operations further include:

transmitting, to the wireless device, downlink data via the PDSCH; and

receiving, from the wireless device, uplink data via the PUSCH.

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7. The base station of claim 1, wherein the number of the OFDM symbols is a maximum of 14.

8. A wireless device, comprising:

a transceiver;

a receiver; and

a controller which controls the transceiver and receiver thereby performing operations including:

receiving, from a base station, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource,

wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols,

wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and

wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and

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receiving, from the base station, downlink control information (DCI), including a field including a bit string,

wherein the bit string in the field relates to a row index of an allocation table, and

wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot.

9. The wireless device of claim 8, wherein the bit string is 3 bits in length.

10. The wireless device of claim 8, wherein the DCI further includes information on one or more allocations of a frequency-domain resource.

11. The wireless device of claim 8, wherein the wireless device supports a new radio access technology (NR).

12. The wireless device of claim 8, wherein the wireless device supports different numerologies which are defined by a subcarrier spacing (SCS).

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13. The wireless device of claim 8, wherein the operations further include:

receiving, from the base station, downlink data via the PDSCH; and

transmitting, to the base station, uplink data via the PUSCH.

14. The wireless device of claim 8, wherein the number of the OFDM symbols is a maximum of 14.

15. An operation method of wireless device, comprising:

receiving, from a base station, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource,

wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols,

wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and

wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and

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receiving, from the base station, downlink control information (DCI), including a field including a bit string,

wherein the bit string in the field relates to a row index of an allocation table, and

wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot.

16. The method of claim 15, wherein the bit string is 3 bits in length.

17. The method of claim 15, wherein the DCI further includes information on one or more allocations of a frequency-domain resource.

18. The method of claim 15, wherein the wireless device supports a new radio access technology (NR).

19. The method of claim 18, wherein the wireless device supports different numerologies which are defined by a subcarrier spacing (SCS).

20. The method of claim 18, further comprising:

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receiving, from the base station, downlink data via the PDSCH;

and

transmitting, to the base station, uplink data via the PUSCH.

32. [This paragraph left intentionally blank].

B. The Prosecution History of the '272 Patent

33. Claims 1-20 received a first Office Action allowance with no prior art applied. The Examiner merely stated

Allowable Subject Matters

3. **Claims 23-42** are allowed. The following is an examiner's statement of reasons for allowance.

a. **Claims 23, 30, 37** are allowed over the prior art of record because the Examiner found neither prior art cited in its entirety, nor based on the prior art found any motivation to combine any of the said prior art reference which teach the limitation "wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string, wherein the bit string in the field relates to a row index of an allocation table, and wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot" with respect to the additional claimed subject matter and in particular the specific boundaries as recited in the claim It is noted that the closest prior art, Kim et al (US 2015/0049625 Al) discloses "(par. 0142), the eNB may trigger a desired feedback type index over a PDCCH/EPDCCH according to a

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feedback type index configuration methods as Table 4 delivered through RRC signaling. In a method to implement such dynamic triggering, a feedback type index requesting CSI feedback may be indicated with 3 bits. That is, in Table 4, 3 bits corresponding to [encoding] of a feedback type index may be contained in DCI. For example, in the case in which DCI contains 100 as bits for a corresponding feedback type index, feedback type index 4 may be requested. In another method to implement dynamic triggering, a bitmap for all feedback type indexes requesting CSI feedback may be used. For example, bitmap 1110001 may indicate that the UE is instructed to feed back feedback type indexes 1, 2, 3, and 7. Herein, bits which may be indicated over a PDCCH are limited, the number of possible combinations among all possible feedback type indexes (through, for example, RRC signaling) may be limited. For example, if available feedback type indexes are restricted to indexes 1, 2, 3 and 7, only two bits may be needed to indicate a feedback type index.".

b. However, Kim fails to disclose at least the claim limitations "wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string, wherein the bit string in the field relates to a row index of an allocation table, and wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot". Thus, Kim does not disclose or render obvious the above underlined limitations as claimed. **Claims 24-292 31-362 38-42** are also allowed since they depend on claims 23, 30 and 37 respectively.

34. EX-1002, 0075-0076 (August 16, 2022 Notice of Allowance).

35. The applicant did not submit, and the Examiner did not consider, any of the prior art applied in the Grounds of the present Petition and my analysis.

36. [This paragraph left intentionally blank].

VI. LEVEL OF ORDINARY SKILL IN THE PERTINENT ART

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37. I have been advised that there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including the educational level of active workers in the field at the time of the invention, the sophistication of the technology, the type of problems encountered in the art, and the prior art solutions to those problems.

38. It is my opinion that a person having ordinary skill in the relevant art ("POSITA") at the time of the invention would have been familiar with 3GPP standards and the messages transmitted between components such as base stations and user equipment terminals specifying resource allocation as demonstrated by the prior art references and description in the State of the Art described herein.

39. A POSITA would have knowledge of these concepts through training and work experience, such as by having a bachelor's degree in electrical engineering, computer engineering, or a related discipline, knowledge of the relevant 3GPP standards as of this time, and at least 2 years of experience working in a field involving wireless communications. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background. A person with less than 2 years of experience

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working in a field involving wireless communications could still qualify if the person has additional education that compensates for their lesser experience.

40. [This paragraph left intentionally blank].

VII. CLAIM CONSTRUCTION

41. I understand that the parties in the related litigations have not exchanged proposed claim constructions or submitted claim construction briefing to the Court.

42. The prior art discussed below discloses the claim elements under any reasonable construction of the terms.

43. [This paragraph left intentionally blank].

VIII. UNDERSTANDING OF THE LAW

44. In expressing my opinions and considering the subject matter of the claims of the '272 patent, I am relying upon certain basic legal principles that have been explained to me. I have been informed by counsel that a patent claim is unpatentable as anticipated under 35 U.S.C. § 102 if each element of that claim is present either expressly or inherently in a single prior art reference. I have also been informed that, to be an inherent disclosure, the prior art reference must necessarily disclose the limitation, and the fact that the

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reference might possibly practice or contain a claimed limitation is insufficient to establish that the reference inherently teaches the limitation.

45. I have been informed that a claimed invention is unpatentable under 35 U.S.C. § 103, if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been informed by counsel that the obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

46. I have been informed by counsel that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a

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finite number of identified, predictable solutions, with a reasonable expectation of success; and (f) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

47. Finally, I understand that secondary factors may be considered in an obviousness inquiry. I understand that these are also referred to as secondary considerations and may include evidence of long-felt need, failure of others, skepticism of those of skill in the art, licensing, commercial success, recognition in the industry, acquiescence, evidence of copying, and unexpected results. While these secondary considerations must be taken into account, they do not necessarily control the obviousness determination.

48. Moreover, for objective evidence of nonobviousness to be accorded substantial weight, I understand that the proponent of such evidence must establish a "nexus" between the evidence and the merits of the patent at issue. Specifically, I understand that the secondary consideration must be tied to the merits of the claimed invention of the patent at issue. Where the alleged secondary consideration results from something other than what is

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both claimed and novel, I understand that there is no nexus to the merits of the claimed invention and the secondary considerations are thus not indicative of nonobviousness. I also understand that it is the patentee's burden to come forward with evidence that a nexus exists.

49. [This paragraph left intentionally blank].

IX. SCOPE AND CONTENT OF THE PRIOR ART

A. Gao (EX-1007).

50. Like the '272 patent, Gao teaches a BS that allocates time-domain resources more granularly than previous LTE systems – at an OFDM symbol granularity. Gao teaches that "time units" can be broken down into different "regions" of OFDM symbols:

> Disclosed in the present application are a data transmission method and a device, comprising: dividing a time unit into DL areas, a time unit including at least two DL areas; notifying a terminal of the divided DL areas by means of configuration signaling. The terminal receiving the configuration signaling; according to said configuration signaling, determining DL areas into which a time unit is divided. Using the present application, defining at least two DL detection areas in a time unit, a terminal detects a downlink transmission in each detection area, and, when one is detected, performs ACK/NACK feedback in an uplink area corresponding to said downlink area. In the present invention, each

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downlink area has a defined feedback and scheduling relationship, respectively, by means of dividing a time unit into multiple downlink areas, thereby increasing scheduling flexibility and system resource utilization.

51. Gao at Abstract.

52. Gao teaches allocating resources by defining a set of patterns that identify the specific time-domain resources for "regions" within a "time-unit."

53. Figure 5 from Gao shows an example of the different regions within a time unit.

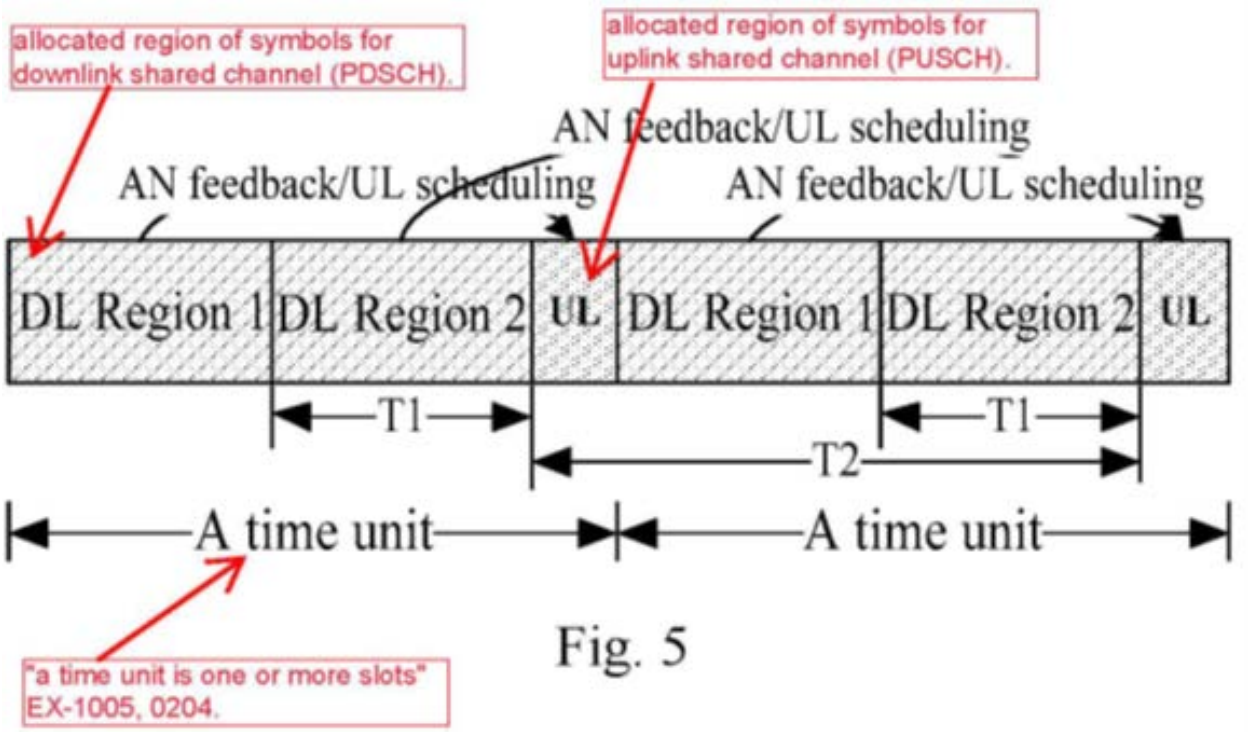

Fig. 5

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54. Gao, Figure 5.[2]

55. Like the '272 patent, Gao identifies "slots" as a basis for a time unit. "In an implementation, a time unit is one or more slots, or one or more sub-frames." EX-1007, 0204.

56. Gao's "regions" are defined on a time-domain basis by identify specific OFDM symbols.

> Particularly, the downlink control channel can indicate a feedback delay or a feedback time sequence or a feedback position index for the UE to determine a resource (e.g., a symbol or a mini-slot) for feeding back ACK/NACK in a corresponding UL region; and the downlink control channel can indicate a scheduling delay or a scheduling time sequence or a scheduling position index for the UE to determine a resource (e.g., a symbol or a mini-slot) for transmitting an uplink shared channel in a corresponding UL region.

57. EX-1007, 0137

> [0140] The sizes of respective DL regions in a time unit may or may not be the same; and for example, there are <u>two symbols in the first DL region, and three symbols in the second DL region</u>.

58. EX-1007, 0140.

[2] Unless otherwise noted, all emphases and annotations herein are added.

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[0147] FIG. 4 is a schematic diagram of an allocation of and a correspondence relationship between uplink and downlink resources of a system with a TA and/or a switching period of time according to a first embodiment of the invention, and FIG. 5 is a schematic diagram of an allocation of and a correspondence relationship between uplink and downlink resources of a system without any TA and/or switching period of time according to the first embodiment of the invention. As illustrated in FIG. 4, for example, an eNB decides to divide a time unit into two DL regions and one UL region, and there is such a blank region or a [guard period] (GP) region between a DL region and the UL region that is a reserved region determined to satisfy a Timing Advance (TA) demand of the UL, a switching period of time from the DL to the UL, etc., possibly taking into account interference between adjacent cells, and other factors. Of course, if a TA or a switching period of time or anti-interference is not required, then there may be no blank component or GP component as illustrated in FIG. 5. A correspondence relationship between the DL regions and the UL region can be predefined or configured directly, and for example, the first DL region in a time unit is predefined or configured to schedule uplink transmission in the UL region in the time unit (where uplink transmission in the UL region may occupy only a part of Orthogonal Frequency Division Multiplexing (OFDM) or Single-Carrier Frequency Division Multiple Access (SC-FDMA) symbols or a part of mini-slots in the UL region, so a plurality of uplink shared channels of the same or different UEs can be transmitted in a UL region in a Time Division Multiplexing (TDM) mode, or uplink transmission in the UL

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region may occupy the length of the entire UL region, and the same will apply hereinafter), the second DL region in a time unit is predefined or configured to schedule uplink transmission in the UL region in the next time unit, ACK/NACK for downlink transmission in the first DL region in a time unit (where downlink transmission in the DL region may occupy only a part of OFDM symbols or a part of mini-slots in the DL region, so a plurality of downlink transmission instances of the same or different UEs can be transmitted in a DL region in a TDM mode, or downlink transmission in the DL region may occupy the length of the entire DL region) is fed back in the UL region in the time unit (an uplink channel carrying ACK/NACK feedback information for downlink transmission may occupy only a part of OFDM or SC-OFDM symbols or a part of mini-slots in the UL region, so a plurality of uplink channels, carrying ACK/NACK, of the same or different UEs can be transmitted in a UL region in a TDM mode, or the uplink channel may occupy the length of the entire UL region, and the same will apply hereinafter), and ACK/NACK for downlink transmission in the second DL region in a time unit is fed back in the UL region in the next time unit, as illustrated in FIG. 4 and FIG. 5. Of course, alternatively the value of T can be predefined or configured, and an UL region spaced from a DL region by a period T of time after the DL region can be defined as a corresponding UL region, for the same effect of the correspondence relationship predefined or configured as above, as illustrated in FIG. 4 and FIG. 5. The length of T may vary from one DL region to another, and the value of T for defining a scheduling relationship may or may not be the same as the value of T for defining a feedback relationship.

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> When a time unit is divided differently into DL and UL regions, the corresponding value of T will also be different, and for example, there are different allocations of DL and UL regions for different services. In this embodiment, a time unit can be a slot or a sub-frame; or course, alternatively a time unit with another length can be defined.

59. EX-1007, 0147.

60. Thus, Gao defines allocation for regions to be on a symbol basis in the time-domain.

61. Gao's base station transmits resource allocation information to the user equipment device with a "notifying module" (for example) that transmits information to the UE including the following:

> [0031] Optionally, the notifying module is configured to notify the UE of the allocated DL regions via the configuration signaling by: notifying the UE of lengths and positions of the DL regions in the time unit; or notifying the UE of one of a plurality of predefined patterns, wherein each pattern includes an allocation of lengths and positions of the DL regions in the time unit; or notifying the UE of start or end positions of the DL regions in the time unit.
>
> [0032] Optionally, the notifying module is further configured to notify the UE of a UL region and/or a GP region in the time unit via the configuration signaling by: notifying the UE of a length and a position of the UL region in the time unit; or notifying the UE of one of a predefined patterns, wherein each pattern includes an allocation of a length and a position of the UL region in the time unit; or notifying the

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> UE of a start or end position of the UL region in the time unit; or notifying the UE of indication information so that the UE determines the UL region in the time unit according to the indication information under a predefined rule.

62. EX-1007, 0031-0032. Thus, the predetermined patterns specifically identify the time-domain extents of regions by indicating a position and length. Because the time-domain is specified in terms of symbols, these patterns indicate a position (starting symbol) of the region and a length (number of symbols of the region) in the time domain. This same content is largely found throughout Gao. E.g., EX-1007, 0011-0012, 0021-0022; 0041-0042, 0051-0052, 0061-0062, 0095, 0106-0111, 0191-0192, 0206-0207, 0223-0224, 0239-0240.

63. Gao will pre-configure the regions (which corresponds to the quote above about a "predefined pattern") and transmit the pre-configuration / predefined patterns using Radio Resource Control (RRC) signals to the UE. RRC signals are also understood to be "semi-static" configuration as Gao states:

> [0179] Of course, the eNB can further pre-configure a DL region to be detected by the UE, and this configuration can be made semi-statically via RRC signaling, or can be made by transmitting configuration signaling periodically, where the periodicity can be changed as needed

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in reality; and for example, a part of UEs are configured to detect only the DL region 1 for a downlink control channel, and the other UEs are configured to detect only the DL region 2 for a downlink control channel, so if the eNB is going into schedule uplink or downlink transmission of the UEs, then it will transmit downlink control channels of these UEs in only the DL detection areas configured for these UEs.

64. EX-1007, [0179].

65. After transmitting the set of "patterns" to the UE using RRC as quoted above, the base station will notify the UE of the specific region by using configuration signaling as quoted in 0031 above (repeated below):

[0031] Optionally, the notifying module is configured to notify the UE of the allocated DL regions via the configuration signaling by: notifying the UE of lengths and positions of the DL regions in the time unit; or notifying the UE of one of a plurality of predefined patterns, wherein each pattern includes an allocation of lengths and positions of the DL regions in the time unit; or notifying the UE of start or end positions of the DL regions in the time unit.

[0032] Optionally, the notifying module is further configured to notify the UE of a UL region and/or a GP region in the time unit via the configuration signaling by: notifying the UE of a length and a position of the UL region in the time unit; or notifying the UE of one of a predefined patterns, wherein each pattern includes an allocation of a length and a position of the UL region in the time unit; or notifying the UE of a start or end position of the UL region in the time unit; or

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notifying the UE of indication information so that the UE determines the UL region in the time unit according to the indication information under a predefined rule.

66. EX-1007, 0031-0032.

67. The "configuration signaling" identifying the specific predefined pattern includes through downlink control information (DCI):

[0150] In another implementation, the eNB transmits configuration signaling over a specific resource in a predefined DL region in each time unit, or one of a plurality of time units (e.g., the first N OFDM symbols in a time unit), where the configuration signaling can be transmitted over a data channel (e.g., like a System Information Block (SIB)), or can be transmitted in a control channel (e.g., in a preset Downlink Control Information (DCI) format in a common search space).

68. EX-1007, 0150.

69. Thus, Gao teaches transmitted patterns with regions using RRC and identifying those patterns with information bits in the DCI. The regions allocate specific time-domain regions on an OFDM symbol basis by identifying the position (start symbol) and length (number of symbols).

70. [This paragraph left intentionally blank].

B. You (EX-1004)

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71. You teaches "Control information reception method and user equipment, and control information transmission method and base station." EX-1004, Title.

72. You teaches the allocation of resources that are transmitted to the UE by the BS. As noted above, the prior art LTE systems allocated time-domain resources generally on a sub-frame basis. You provides for a more granular resource allocation:

> Provided are method and device for transmitting/receiving control information. A downlink grant can comprise information indicating whether or not an uplink grant is transmitted in the same subframe. If the information indicates that an uplink grant exists, a user equipment attempts detection of the uplink grant in the same subframe in which the downlink grant is received. If not, the user equipment does not attempt detection of the uplink grant. For low latency, the subframe can be shorter than an existing subframe.

73. EX-1004, Abstract.

74. You is similar to Gao and the '272 patent in providing for a BS to allocate resources on an OFDM symbol level rather than at the level of an LTE subframe.

75. You teaches the then-existing LTE allocation on a subframe basis in the time domain:

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> [0003] A general wireless communication system performs data transmission/reception through one downlink (DL) band and through one uplink (UL) band corresponding to the DL band (in case of a frequency division duplex (FDD) mode), or divides a prescribed radio frame into a UL time unit and a DL time unit in the time domain and then performs data transmission/reception through the UL/DL time unit (in case of a time division duplex (TDD) mode). A base station (BS) and a user equipment (UE) transmit and receive data and/or control information scheduled on a prescribed time unit basis, e.g. on a subframe basis. The data is transmitted and received through a data region configured in a UL/DL subframe and the control information is transmitted and received through a control region configured in the UL/DL subframe. To this end, various physical channels carrying radio signals are formed in the UL/DL subframe. In contrast, carrier aggregation technology serves to use a wider UL/DL bandwidth by aggregating a plurality of UL/DL frequency blocks in order to use a broader frequency band so that more signals relative to signals when a single carrier is used can be simultaneously processed.

76. EX-1004, 0003

77. You explains that LTE prior art system transmits data in "frames." Figure 1(a) of You depicts this LTE frame:

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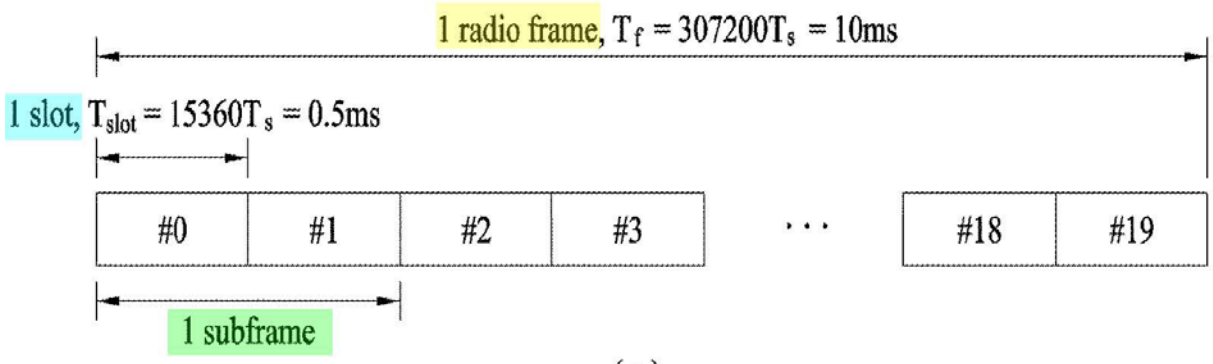
FIG. 1



78. (a)

79. EX-1004, Fig. 1(a). An LTE frame contained 10 "subframes" each including two "slots."

[0056] FIG. 1 illustrates the structure of a radio frame used in a wireless communication system.

[0057] Specifically, FIG. 1(a) illustrates an exemplary structure of a radio frame which can be used in frequency division multiplexing (FDD) in 3GPP LTE/LTE-A and FIG. 1(b) illustrates an exemplary structure of a radio frame which can be used in time division multiplexing (TDD) in 3GPP LTE/LTE-A. The frame structure of FIG. 1(a) is referred to as frame structure type 1 (FS1) and the frame structure of FIG. 1(b) is referred to as frame structure type 2 (FS2).

[0058] Referring to FIG. 1, a 3GPP LTE/LTE-A radio frame is 10 ms (307,200Ts) in duration. The radio frame is divided into 10 subframes of equal size. Subframe numbers may be assigned to the 10 subframes within one radio frame, respectively. Here, Ts denotes sampling time

> where Ts=1/(2048*15 kHz). Each subframe is 1 ms long and is further divided into two slots. 20 slots are sequentially numbered from 0 to 19 in one radio frame. Duration of each slot is 0.5 ms. A time interval in which one subframe is transmitted is defined as a transmission time interval (TTI). Time resources may be distinguished by a radio frame number (or radio frame index), a subframe number (or subframe index), a slot number (or slot index), and the like.

80. EX-1004, 0056-0058.

81. The LTE "slots" comprise "resources" used to transmit data from the base station to the user equipment. You's Fig. 2 depicts the LTE "slot."

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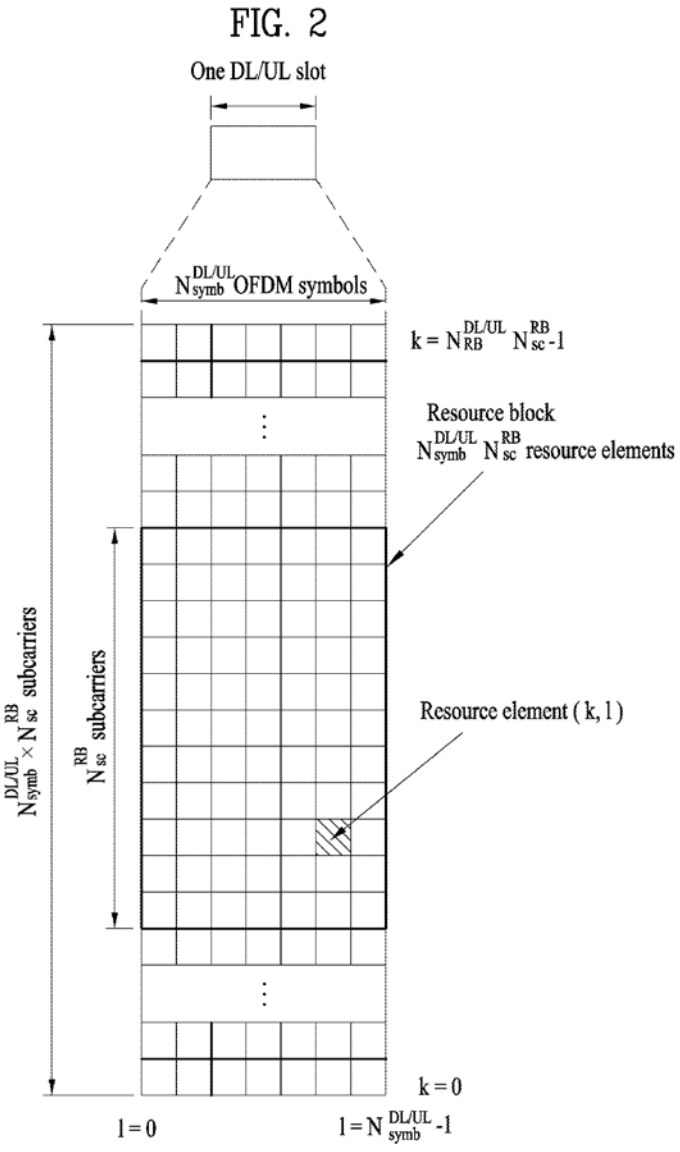

82.

83. EX-1004, Fig. 2.

84. In the "time domain" (horizontally), the slot is seven OFDM symbols. In the "frequency domain" (vertically) the slot is different "subcarriers" (*i.e.*, different frequencies).

[0062] Referring to FIG. 2, a slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in the time domain

and includes a plurality of resource blocks (RBs) in the frequency domain. The OFDM symbol may refer to one symbol duration. Referring to FIG. 2, a signal transmitted in each slot may be expressed by a resource grid including NDL/UL RB*NRB sc subcarriers and NDL/UL symb OFDM symbols. NDL RB denotes the number of RBs in a DL slot and NUL RB denotes the number of RBs in a UL slot. NDL RB and NUL RB depend on a DL transmission bandwidth and a UL transmission bandwidth, respectively. NDL symb denotes the number of OFDM symbols in a DL slot, NUL symb denotes the number of OFDM symbols in a UL slot, and NRB sc denotes the number of subcarriers configuring one RB.

[0063] An OFDM symbol may be referred to as an OFDM symbol, a single carrier frequency division multiplexing (SC-FDM) symbol, etc. according to multiple access schemes. The number of OFDM symbols included in one slot may be varied according to channel bandwidths and CP lengths. For example, in a normal cyclic prefix (CP) case, one slot includes 7 OFDM symbols. In an extended CP case, one slot includes 6 OFDM symbols. Although one slot of a subframe including 7 OFDM symbols is shown in FIG. 2 for convenience of description, embodiments of the present invention are similarly applicable to subframes having a different number of OFDM symbols. Referring to FIG. 2, each OFDM symbol includes NDL/UL RB*NRB sc subcarriers in the frequency domain. The type of the subcarrier may be divided into a data subcarrier for data transmission, a reference signal (RS) subcarrier for RS transmission, and a null subcarrier for a guard band and a DC component. The null subcarrier for the DC component is

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> unused and is mapped to a carrier frequency f0 in a process of generating an OFDM signal or in a frequency up-conversion process. The carrier frequency is also called a center frequency fc.
>
> [0064] One RB is defined as NDL/UL symb (e.g. 7) consecutive OFDM symbols in the time domain and as NRB sc (e.g. 12) consecutive subcarriers in the frequency domain. For reference, a resource composed of one OFDM symbol and one subcarrier is referred to a resource element (RE) or tone. Accordingly, one RB includes NDL/UL symb*NRB sc REs. Each RE within a resource grid may be uniquely defined by an index pair (k,l) within one slot. k is an index ranging from 0 to NDL/UL RB*NRB sc−1 in the frequency domain, and 1 is an index ranging from 0 to N DL/UL symb1−1 in the time domain.
>
> [0065] Meanwhile, one RB is mapped to one physical resource block (PRB) and one virtual resource block (VRB). A PRB is defined as NDL symb (e.g. 7) consecutive OFDM or SC-FDM symbols in the time domain and NRB sc (e.g. 12) consecutive subcarriers in the frequency domain. Accordingly, one PRB is configured with NDL/UL symb*NRB sc REs. In one subframe, two RBs each located in two slots of the subframe while occupying the same NRB sc consecutive subcarriers are referred to as a physical resource block (PRB) pair. Two RBs configuring a PRB pair have the same PRB number (or the same PRB index).

85. EX-1004, 0062-0065.

86. Thus, in LTE (and in the subsequent NR (new radio) 5G systems), a "resource element" is identified by a particular "time" (which OFDM

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symbol in the time domain) on a particular "frequency" (which particular subcarrier). EX-1004, 0064 (quoted above).

87. The resources are allocated for either the BS to transmit data to the UE (on a downlink shared channel [PDSCH]) or the UE to transmit data to the BS (on an uplink shared channel [PUSCH]).

[0053] In the present invention, a physical downlink control channel (PDCCH), a physical control format indicator channel (PCFICH), a physical hybrid automatic retransmit request indicator channel (PHICH), and a physical downlink shared channel (PDSCH) refer to a set of time-frequency resources or resource elements (REs) carrying downlink control information (DCI), a set of time-frequency resources or REs carrying a control format indicator (CFI), a set of time-frequency resources or REs carrying downlink acknowledgement (ACK)/negative ACK (NACK), and a set of time-frequency resources or REs carrying downlink data, respectively. In addition, a physical uplink control channel (PUCCH), a physical uplink shared channel (PUSCH) and a physical random access channel (PRACH) refer to a set of time-frequency resources or REs carrying uplink control information (UCI), a set of time-frequency resources or REs carrying uplink data and a set of time-frequency resources or REs carrying random access signals, respectively. In the present invention, in particular, a time-frequency resource or RE that is assigned to or belongs to PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH is

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> referred to as PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH RE or PDCCH/PCFICH/PHICH/PDSCH/PUCCH/PUSCH/PRACH time-frequency resource, respectively. Therefore, in the present invention, PUCCH/PUSCH/PRACH transmission of a UE is conceptually identical to UCI/uplink data/random access signal transmission on PUSCH/PUCCH/PRACH, respectively. In addition, PDCCH/PCFICH/PHICH/PDSCH transmission of an eNB is conceptually identical to downlink data/DCI transmission on PDCCH/PCFICH/PHICH/PDSCH, respectively.

88.EX-1004, 0053.

89. Like Gao, You discloses a BS that allocates resources more granularly than was known in LTE systems described above. You allocates resources in the time-domain on an OFDM symbol level. For example, You can allocate regions of less than 7 symbols:

90.

> [0144] Referring to FIG. 6, a propagation delay (PD), a buffering time, a decoding time, an A/N preparation time, an uplink PD, and an OTA (over the air) delay according to a retransmission margin are produced while a signal transmitted from the eNB reaches the UE, the UE transmits an A/N for the signal, and the A/N reaches the eNB. To satisfy low latency, a shortened TTI (sTTI) shorter than or equal to 0.5 ms needs to be designed by shortening the TTI, which is the smallest unit of data transmission. For example, to shorten the OTA delay, which is

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a time taken from the moment the eNB starts to transmit data (PDCCH and PDSCH) until the UE completes transmission of an A/N for the data to the eNB, to a time shorter than 1 ms, the TTI is preferably set to 0.21 ms. That is, to shorten the user plane (U-plane) delay to 1 ms, the sTTI may be set in the unit of about three OFDM symbols.

[0145] While FIG. 6 illustrates that the sTTI is configured with three OFDM symbols to satisfy 1 ms as the OTA delay or U-plane delay, an sTTI shorter than 1 ms may also be configured. For example, for the normal CP, an sTTI consisting of 2 OFDM symbols, an sTTI consisting of 4 OFDM symbols and/or an sTTI consisting of 7 OFDM symbols may be configured.

[0146] In the time domain, all OFDM symbols constituting a default TTI or the OFDM symbols except the OFDM symbols occupying the PDCCH region of the TTI may be divided into two or more sTTIs on some or all frequency resources in the frequency band of the default TTI, namely the channel band or system band of the TTI.

91. EX-1004, 0144-0146.

92. Like Gao, You discloses "resource patterns" that define "regions" of allocated OFDM symbols for channels such as PDSCH.

[0221] Method 7. Resource Pattern Indication

[0222] To reduce the size of a resource allocation (RA) field of DCI, each value indicated by the RA field may mean a specific sPDSCH transmission resource pattern. For example, a pattern actually applied to an sPDSCH among 2N sPDSCH transmission resource patterns may be indicated to the UE through N bits. Such an sPDSCH transmission

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> resource pattern may indicate only a PRB resource region in which the sPDSCH is transmitted. Alternatively, the sPDSCH transmission resource pattern may indicate not only the PRB resource region in which the sPDSCH is transmitted but also a resource region in which the sPDSCH is transmitted within an OFDM symbol region in which the sPDCCH is transmitted in the PRB resource region in which the sPDSCH is transmitted.

93. EX-1004, 0221-0222. The "resource regions" within an "OFDM symbol region" are defined in You as being comprised of OFDM symbols as noted above.

94. Like Gao, You's BS transmits the "patterns" with "regions" allocating OFDM symbols to the UE using RRC signals.

> [0224] Each sPDSCH transmission resource pattern indicated by the RA field may be configured by an RRC layer. The UE may receive configuration information about the sPDSCH transmission resource pattern(s) through an RRC signal and determine that one of the sPDSCH transmission resource pattern(s) configured by the RRC signal is an sPDSCH transmission resource, based on the value of the RA field.

95. EX-1004, 0224.

96. Like Gao, You's BS uses the DCI to "index" into the resource patterns. You explicitly implements bits in the "(RA) field of DCI" to provide such an index

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[0221] Method 7. Resource Pattern Indication

[0222] To reduce the size of a resource allocation (RA) field of DCI, each value indicated by the RA field may mean a specific sPDSCH transmission resource pattern. For example, a pattern actually applied to an sPDSCH among 2N sPDSCH transmission resource patterns may be indicated to the UE through N bits. Such an sPDSCH transmission resource pattern may indicate only a PRB resource region in which the sPDSCH is transmitted. Alternatively, the sPDSCH transmission resource pattern may indicate not only the PRB resource region in which the sPDSCH is transmitted but also a resource region in which the sPDSCH is transmitted within an OFDM symbol region in which the sPDCCH is transmitted in the PRB resource region in which the sPDSCH is transmitted.

97. EX-1004, 0221-0222. You references these DCI RA field bits as a "pattern index." EX-1004, 0223.

98. I also note that similar to Gao, You is assigned to a company (LG) that contributed to the 3GPP NR "discussions" cited by the '272 patent as I have detailed below. For example, in R1-1610129 (which I discuss in detail below), LG suggested that OFDM symbols could be allocated at "mini-slot" levels of 2 OFDM symbols. EX-1020, at 10. This is consistent with You's teaching as I have mentioned above.

99. Thus, You (like Gao) reflects the concepts that the '272 patent cited as being "discussed" in the 3GPP working groups prior to the Priority

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Application – including the concepts of more granular resource allocation at an OFDM symbol level.

100. [This paragraph left intentionally blank].

C. 3GPP TS 36.213 v. 13.1.0 (EX-1010) ("3GPP36-213") and 3GPP TS 36.212 v. 13.1.0 (EX-1011) ("3GPP36-212")

101. 3GPP36-213 is entitled "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 13)."

102. 3GPP36-213 "specifies and establishes the characteristics of the physicals layer procedures in the FDD and TDD modes of E-UTRA." 3GPP36-213 at Section 1 ("Scope"). 3GPP36-213 identifies other "References" "which, through reference in this text, constitute provisions of" 3GPP36-213. 3GPP36-213, Section 2. 3GPP36-213 expressly cross-references 3GPP36-212 (discussed herein). 3GPP36-213, Section 2.

103. 3GPP36-212 is entitled "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding (Release 13)."

104. 3GPP36-212 "specifies the coding, multiplexing and mapping to physical channels for E-UTRA." 3GPP36-212 at Section 1 ("Scope").

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3GPP36-212 identifies other "References" "which, through reference in this text, constitute provisions of" 3GPP36-212. 21, Section 2. 3GPP36-212 expressly cross-references 3GPP36-213 (discussed herein). 3GPP36-2123, Section 2.

105. 3GPP36-213 and 3GPP36-212 disclose LTE technology that was known, and adopted, no later than March 2016 as reflected in the date on the first page of 3GPP36-213 and in Mr. Bishop's accompanying declaration, EX-1012.

106. 3GPP36-213 and 3GPP36-212 teach one example of known resource allocation tables indexed by DCI bits that would have been known to a POSITA prior to the Priority Date.

107. 3GPP36-213 teaches the same implementation / format of resource allocation table used in the Priority Application as shown in the comparison below:

<table>
<tr>
<td>TS36213
(March 2016)
(EX-1010),
Section 8.1.3</td>
<td>8.1.3 Uplink resource allocation type 2

Table 8.1.3-1: ….

<table>
<tr><th>Value of resource allocation field</th><th>Allocated resource blocks</th></tr>
<tr><td>‘000’</td><td>0</td></tr>
<tr><td>‘001’</td><td>1</td></tr>
<tr><td>‘010’</td><td>2</td></tr>
<tr><td>‘011’</td><td>3</td></tr>
<tr><td>‘100’</td><td>4</td></tr>
<tr><td>‘101’</td><td>5</td></tr>
<tr><td>‘110’</td><td>0 and 1</td></tr>
</table>
</td>
</tr>
</table>

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<table>
<tr><td></td><td>
<table>
<tr><td>'111'</td><td>2 and 3</td></tr>
</table>
</td></tr>
<tr><td>Priority Application (October 31, 2016) (EX-1015) at 0063.</td><td>
Examples of symbol allocation table
<table>
<tr><th>Symbol allocation field in DCI</th><th>Allocated symbol indices for PDSCH(or PUSCH)</th></tr>
<tr><td>000</td><td>0,1,2,3,4,5,6</td></tr>
<tr><td>001</td><td>0,1,2,3</td></tr>
<tr><td>010</td><td>0,1,4,5,6</td></tr>
<tr><td>011</td><td>2,3,4,5,6</td></tr>
<tr><td>100</td><td>0,1</td></tr>
<tr><td>101</td><td>2,3</td></tr>
<tr><td>110</td><td>4,5,6</td></tr>
<tr><td>111</td><td>reserved</td></tr>
</table>
</td></tr>
</table>

108. As is readily apparent from the comparison above, the '272 Priority Application used an almost verbatim copy of Table 8.1.3-1 from 3GPP36-213. In the left column are the bits of the "resource allocation field" which the '272 patent renamed as the "symbol allocation field" because the '272 patent sought to allocate resources at the symbol level as I have discussed herein.

109. In the right column, 3GPP36-213 shows the resources that are allocated. Because LTE allocates on a resource block level, it shows the specific resource blocks. In the right column, the Priority Application shows the allocated symbol indices. Because the Priority Application sought to allocate resources on a symbol level, it renamed the "Allocated resource" to be "Allocated symbol."

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110. 3GPP36-212 taught using DCI bits to index into the resource allocation table (later adopted by the Priority Application).

> 5.3.3.1.11 Format 6-0B
>
> **DCI format** 6-0B is used for the scheduling of PUSCH in one UL cell.
>
> The following information is transmitted **by means of the DCI format** 6-0B: …
>
> - 3 bits provide the resource allocation within the indicated narrowband as specified in section 8.1.3 of [3] ….

111. EX-1011, Section 5.1.3.1.11. Reference "[3]" is "3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures." EX-1011, Section 2.

112. Thus, based upon the language in Section 2 of each of 3GPP36-213 and 3GPP36-212, the disclosures in which 3GPP36-213 and 3GPP36-212 cross-reference each other would indicate that these are the same references. E.g., 3GPP36-213 and 3GPP36-212 at Section 2 ("The following documents contain provisions which, through reference in this text, constitute provisions of the present document."). At a very minimum, a POSITA would consider it obvious to combine these references with a reasonable expectation of success as they are part of the same overall wireless standard, part of the same revision, were adopted together and

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explicitly cross-reference each other include the specific information (and sections) relied upon herein.

113. 3GPP36-213 and 3GPP36-212 show one example known to a POSITA for allocating and indicating allocation thereof of resources (including symbols). Thus, using three DCI bits to index a resource allocation table was known and adopted by 3GPP at least seven months prior to the Priority Date as shown above.

114. [This paragraph left intentionally blank].

D. RAN1#86-BIS Working Group Materials Including R1-1610129 and RAN1#86-BIS Meeting Minutes.

115. RAN1 is responsible for developing and promulgating portions of the 3GPP standards:

> Within the 3GPP Technical Specification Group Radio Access Network (TSG RAN), RAN WG1 (RAN1) is responsible for the development of specifications dealing with evolved UTRA, 5G NR, and beyond.
>
> RAN1 is responsible for specification of the physical layer of the radio Interfaces for UE, Evolved UTRAN, NG-RAN, and beyond. The work in RAN1 includes especially:

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- Specification of physical channels and modulation
- Specification of physical layer multiplexing, channel coding and error detection
- Specification of physical layer procedures (both control and data)
- Specification of definition of measurements and their provision by the physical layer to the upper layers

RAN1 also specifies handling of physical layer related UE capabilities and parameters used in device tests.

116. https://www.3gpp.org/3gpp-groups/radio-access-networks-ran/ran-wg1.

117. The Priority Application acknowledged that it took materials from RAN1#86-BIS, but the applicants deleted that reference when presenting the application to the Examiner. See EX-1016 at 0036 (which is deleted from the '272 patent).

118. The RAN1#86-Bis Meeting Minutes were plainly publicly available and known – including to the inventor before the Priority Date. For example, the Priority Application explicitly copied portions of those Meeting Minutes into the Priority Application. Compare EX-1001, 7:61-8:14 and EX-1015 (and translation in EX-1016), 0039-0052 with EX-1021, 0137 (RAN1#86-BIS Minutes).

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119. One inventor (Woo-Jin Choi) attended RAN1#86-BIS and RAN1#86 according to the official documents that reflect attendance. EX-1018, EX-1019.

120. As detailed herein, the '272 patent repeatedly references "discussions" in the NR working groups as being part of the basis for the specification disclosure of the '272 patent. E.g., EX-1001, 1:27-2:3, 2:7-35, 6:26-9:4.

121. These "discussions" included the concept of allocating resources at a more refined granularity than was known in LTE (as discussed herein). EX-1001, 1:50-59, 2:7-33.

> To support requirements, there also have been discussions on i) a method of multiplexing at least one numerology each having different subcarrier spacing values from another over one NR carrier using TDM, FDM or TDM/FDM technique, and ii) a method of supporting <u>one or more time units in configuring a scheduling unit in the time domain</u>.
> In this regard, in the NR, a subframe has been defined as one type of time domain structure. A single subframe duration having 14 OFDM symbols of 15 kHz sub-carrier spacing (SCS)-based normal CP overhead, like the LTE has been defined as a reference numerology for defining the subframe duration.
> Therefore, the subframe of the NR has a time duration of 1 ms. However, unlike the LTE, since the subframe of the NR is an absolute reference time duration, <u>a slot and a mini-slot may be defined as a time unit used for an actual UL/DL data scheduling</u>.

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> In this case, the number of OFDM symbols forming a slot, a value of y, has been defined as y=14 regardless of the numerology.
>
> Therefore, a slot may be formed of 14 symbols. In addition, according to transmission direction for the slot, all symbols may be used for DL transmission or UL transmission, or the symbols may be used in the configuration of a DL portion+a gap+an UL portion.
>
> Further, a mini-slot formed of fewer symbols than the typical slot has been defined in a numerology (or SCS). Therefore, a short time-domain scheduling interval for UL/DL data transmission/reception may be set based on the mini-slot. Also, a long time-domain scheduling interval for UL/DL data transmission/reception may be set using slot aggregation.
>
> Particularly, as in the URLLC, in case latency critical data are transmitted/received, it may be difficult to satisfy a latency requirement when scheduling is performed based on a unit of a slot based on 1 ms defined in a frame structure based on a numerology having a small SCS value, for example, 15 kHz. To this end, it is possible to define a mini-slot formed of fewer orthogonal frequency division multiple symbols than the typical slot. Thus, it is possible to define the scheduling for the latency critical data, as in the URLLC, to be performed based on the mini-slot.

122. EX-1001, 6:52-7:29

123. R1-1610129 provides a "summary" of these "discussions" upon which the '272 patent based its specification.

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124. R1-1610129 teaches that it was already well-known to a POSITA to allocate resources on the level of an OFDM symbol (or collection of symbols) at a more refined granularity than the resource allocation performed in the prior art LTE systems.

125. R1-1610129 was a large (prior art) submission by Qualcomm summarizing contributions from many companies.

3GPP TSG-RAN WG1 #86bis **R1-1610129**
10th – 14th October 2016
Lisbon, Portugal

Agenda item:	8.1.2.2
Source:	Qualcomm Incorporated
Title:	Summary of [86-19] Discussion on Slot Structure Use Cases
Document for:	Discussion/Decision

126. EX-1020. The "Description" of R1-161029 was to identify previous agreements and to summarize known proposals from various industry groups. E.g. EX-1020, 0001.

127. R1-1610129 included various proposals from many companies for allocating time-domain resources at a more granular level than LTE had allocated. These proposals included:

- Fujitsu: "For 15kHz sub-carrier spacing the proposed transmission durations of 7, 4, and 2 symbols match those under discussion for short TTI lengths in LTE. A transmission duration of 1 symbol is proposed to allow NR to exceed LTE capabilities in terms of latency and also allow the possibility for more convenient multiplexing with

transmissions with shorter symbol durations." EX-1020 at 0007, 0018 ("For efficient TDD operation and frequent Tx/Rx switching it should be possible operate with as little as 1 symbol in UL or DL. This 1 symbol should also be available for both control and data (as we pointed out in one of our RAN1 contributions)");

- CATT: "Mini-slot is the minimum scheduling unit … Mini-slot is 1 OFDM symbols." EX-1020 at 0009.
- LG: "Finer scheduling unit can be also considered for eMBB where mini-slot(s) size can be multiple of 2 OS [OFDM symbols]." EX-1020 at 0010.
- ETRI: "Both slot and mini-slot should be supported as scheduling units. Slot is a default scheduling unit and mini-slot is used only when configured. Our preference is 14 symbol slot length and 2 symbol mini-slot length for all numerologies" EX-1020 at 0010.
- Interdigital: allocations of "2 symbols." EX-1020 at 0011.

128. From the context of R1-1610129 and the almost uniform identification of performing resource allocation at the symbol level, it is clear that a POSITA would have known (including through R1-1610129) of allocating time-domain resources at the OFDM symbol level and communicating such allocations to the UE prior to the Priority Date.

129. R1-1610129 exemplifies the '272 patent statements that "discussions" already occurred in the NR working groups and that those "discussions" included time-domain allocations at the OFDM symbol level.

130. **RAN1#86-BIS Meeting Minutes (EX-1021)** cites to R1-1610129 and many other related submissions detailing allocating resources on a more granular level. EX-1021, Section 8.1.2.2.

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131. The Priority Application cited to the RAN1#86-BIS meeting at which R1-1610129 (and many other similar submissions) were presented and quoted from the RAN1#86-BIS Meeting Minutes (EX-1021). EX-1016.

132. [This paragraph left intentionally blank].

E. 3GPP Standards Long Before The Priority Date Defined Resource Allocation Information For Transmissions Between Wireless Components.

133. The basic concept of a base station allocating resources for communications between the base station and user equipment and then transmitting those allocations was known long prior to the Priority Date. Such allocations and communications are a fundamental aspect of 3GPP standards going back decades. Such standards allowed the BS and UE to both have the requisite information regarding the transmissions (such as the specific time-domain resources and frequency domain resources). The '272 patent does not teach anything new or nonobvious regarding such resource allocation and communications.

134. As the '272 patent acknowledges, many concepts described and claimed in the '272 patent were known and used in the 3GPP standards before the Priority Date. For example, before the Priority Date, DCI

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formats that contained "bits" that related to resource allocation were well-known. For example, as shown in 3GPP TS 36.212 (EX-1011), Section 5.3.3 ("Downlink control information") included 20 different "DCI formats." EX-1011 at Section 5.3.3.1.

135. The known 3GPP DCI formats also included "bits" used for resource allocation. For example, in DCI "Format 1," "bits provide the resource allocation" for the "resource block assignments" for the PDSCH channel. EX-1011, Section 5.3.3.1.2. Similar "bits" are used for resource allocation in almost all of the DCI formats. EX-1011, Section 5.3.3.1.

136. The LTE time-domain allocation was generally performed for an entire subframe of 14 OFDM symbols as explained in You and discussed in the You summary herein. In LTE, the "resource block assignments" identified by DCI bits – among other resources – are the different subcarriers (frequencies) that are allocated for the channel (*e.g.*, PDSCH/PUSCH).

137. Thus, using DCI bits to specify resource allocations was well-known and used in 3GPP standards before the Priority Date.

F. The Implementation of Data Structures Known As "Tables" Was Well-Known To A POSITA Long Prior To The Priority Date.

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138. The '272 patent does not explicitly define a "table." The '272 patent and the Priority Application give examples of a "table." For example, the Priority Application teaches the following as an example of a symbol allocation table:

[0063] [Table 1]

Examples of symbol allocation table

Symbol allocation field in DCI	Allocated symbol indices for PDSCH (or PUSCH)
000	0,1,2,3,4,5,6
001	0,1,2,3
010	0,1,4,5,6
011	2.3,4,5,6
100	0,1
101	2,3
110	4,5,6
111	reserved

139. EX-1016, 0063.

140. The '272 patent teaches varying examples of "tables." For example, Table 1 in the '272 patent appears similar to Table 1 in the Priority Application:

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TABLE 1

Symbol allocation field in DCI	Allocated symbol indices for PDSCH(or PUSCH)
000	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
001	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
010	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
011	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
100	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
101	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
110	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
111	3, 4, 5, 6, 7, 8, 9, 10, 11, 12

141. EX-1001, 10:30-40.

142. Figure 4 of the '272 patent is characterized as a "form of a table" in the '272 patent:

Time-interval resource configuration information for a PDSCH (400)

{
{index 0, SOS 0, Length 4}
{index 1, SOS 0, Length 5}
.
.
.
{index 15, SOS 5, Length 1}
}

143. EX-1001, Fig. 4. See EX-1001, 2:56-60 ("FIG. 4 is a diagram illustrating an information sequence of UE-specific higher layer signaling including time-domain resource configuration information in the form of a table for transmitting/receiving the DL data channel (PDSCH) as shown in FIG. 3").

144. Notably, Figure 4 of the '272 patent (and the similar Figure 6) are not present in the Priority Application.

145. I note that the Patent Owner claims priority to the October 31, 2016 application for the Challenged Claims:

11,540,272	1–20	October 31, 2016, as well as the dates of any subsequent applications

146. EX-1012, XXX. Thus, because the Priority Application's Table 1 is the only example of the claimed table, at a very minimum, a structure resembling Table 1 of the Priority Application must teach (or render obvious) the claims. Otherwise, the Patent Owner would have no basis to make the assertion that the claims have Section 112 support in the Priority Application as is made above.

147. Many patents contain structures identified as "tables" in the specification that appear to have similar structure to Table 1 in the Priority Application.

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148. For example, Gao shows a "table" that has a similar structure (albeit, different data content) to Table 1 in the Priority Application:

TABLE 1

Uplink-downlink configu-ration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

149. EX-1004, 0060-0061,

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TABLE 3

Subframe	Number of OFDM symbols for PDCCH when N^{DL}_{RB} >10	Number of OFDM symbols for PDCCH when N^{DL}_{RB} ≤10
Subframe 1 and 6 for frame structure type 2	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 1 or 2 cell-specific antenna ports	1, 2	2
MBSFN subframes on a carrier supporting PDSCH, configured with 4 cell-specific antenna ports	2	2
Subframes on a carrier not supporting PDSCH	0	0
Non-MBSFN subframes (except subframe 6 for frame structure type 2) configured with positioning reference signals	1, 2, 3	2, 3
All other cases	1, 2, 3	2, 3, 4

150. EX-1004, 0070;

151. Unsurprisingly, Gao also includes Tables similar to the structure in Table 1 of the Priority Application.

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TABLE 1

Uplink-downlink configurations.

Uplink-downlink configuration	Downlink-to-Uplink Switching periodicity	Sub-frame number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

TABLE 2

Special sub-frame configurations (including DwPTS/GP/UpPTS lengths).

Special sub-frame configuration	Normal cyclic prefix in downlink			Extended cyclic prefix in downlink		
	DwPTS	UpPTS		DwPTS	UpPTS	
		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink		Normal cyclic prefix in uplink	Extended cyclic prefix in uplink
0	$6592 \cdot T_s$	$(1 + X) \cdot 2192 \cdot T_s$	$(1 + X) \cdot 2560 \cdot T_s$	$7680 \cdot T_s$	$(1 + X) \cdot 2192 \cdot T_s$	$(1 + X) \cdot 2560 \cdot T_s$
1	$19760 \cdot T_s$			$20480 \cdot T_s$		
2	$21952 \cdot T_s$			$23040 \cdot T_s$		
3	$24144 \cdot T_s$			$25600 \cdot T_s$		
4	$26336 \cdot T_s$			$7680 \cdot T_s$	$(2 + X) \cdot 2192 \cdot T_s$	$(2 + X) \cdot 2560 \cdot T_s$
5	$6592 \cdot T_s$	$(2 + X) \cdot 2192 \cdot T_s$	$(2 + X) \cdot 2560 \cdot T_s$	$20480 \cdot T_s$		
6	$19760 \cdot T_s$			$23040 \cdot T_s$		
7	$21952 \cdot T_s$			$12800 \cdot T_s$		
8	$24144 \cdot T_s$			—	—	—
9	$13168 \cdot T_s$			—	—	—

152. EX-1007, 0004-0005.

153. Thus, the data structure format of a "table" as reflected in Table 1 of the Priority Application is not novel or nonobvious. Quite the contrary, such "tables" are pervasive throughout many patents in the communications space.

154. In the context of the '272 patent claims, "table" relates to "a systematic arrangement of data usually in rows and columns for ready reference." Websters. EX-1023.

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155. Similar words express the same concept. EX-1024 (Britannica defining "table" as "a collection of information that is arranged in rows and columns"). The '272 patent and the Priority Application do not teach any particular aspect or feature of the claimed "table" data structure beyond what was already known to POSITAs and used pervasively in patents and in 3GPP standards.

156. Effectively, as shown above and in Table 1 of the Priority Application, "tables" are a known concept to group collections of similar data so that individual components of such data can be efficiently accessed (e.g., the data in a "row" of a table can be accessed together efficiently through the use of a row index identifying that row).

157. This concept of a table as an arrangement of data in rows and columns is used pervasively throughout 3GPP standards. Using the 3GPP document 36.213 v.13.1.0 (EX-1010) as one exemplar, this table concept (known to be arrangements of rows with related information) is pervasively present as shown in the examples below:

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Table 7.1.6-1: Number of repetitions for PDSCH carrying *SystemInformationBlockType1-BR* for BL/CE UE.

Value of *schedulingInfoSIB1-BR-r13*	Number of PDSCH repetitions
0	N/A
1	4
2	8
3	16
4	4
5	8
6	16
7	4
8	8
9	16
10	4
11	8
12	16
13	4
14	8
15	16
16	4
17	8
18	16
19-31	Reserved

158. EX-1010, Tables 7.1.6-1 (showing a systematic arrangement of data in rows and columns for ready reference).

Table 7.1.6.1-1: Type 0 resource allocation RBG size vs. Downlink System Bandwidth

System Bandwidth N_{RB}^{DL}	RBG Size (*P*)
≤10	1
11 – 26	2
27 – 63	3
64 – 110	4

159.

160. EX-1010, Table 7.1.6.1-1.

161. See also EX-1010, 7.1.7.1-1, 7.1.7.1-1A, 7.1.7.1-2, 7.1.7.2.1-1.

162. Thus the "table" as taught in the '272 patent and Priority Application (Table 1) merely reflects the well-known implementation of a data structure that arranges related data in rows and columns for easy and efficient access.

163. The '272 patent did not invent the concept of table data structures, did not provide any specific information regarding the implementation of data structures, and appears to rely on the knowledge of a POSITA to understand tables and their implementation. Such knowledge is available to a POSITA when viewing the prior art including the prior art herein.

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X. THE '272 PATENT IS OBVIOUS.

164. For the '272, I have been asked to provide an opinion as to whether Challenged Claims are obvious over Gao combined with You or You combined with Gao (Grounds 1 and 2) and further when the Challenged Claims are obvious in light of Grounds 1 or 2 in further view of 3GPP36-213 and 3GPP36-212 and further whether claims 5, 12, and 19 are obvious in Grounds 1-4 in further combination with R1-1610129.

165. I have considered the scope and content of the prior art and considered whether any differences between the alleged invention and the prior art are such that the subject matter, as a whole, would have been obvious to a person having ordinary skill in the art at the time of the alleged invention. I have also considered the level of ordinary skill in the pertinent art in performing my analyses.

166. Ground 1 and Ground 2 both rely upon Gao and You. The different Grounds use different primary references because Gao and You each have particularly strong disclosures that supplement the other references as detailed in the individual elements below.

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167. For example, Gao expressly teaches that the resource allocation patterns include the claimed start and length of OFDM resources. *See* Ground 1, [1.5]-[1.6].

168. Similarly, You more explicitly teaches that the DCI contains a specific field specifying an "index" (also referenced as a "pattern index" in You) into the resource allocation patterns (corresponding to the table in the claims) and that the resource patterns are transmitted from the base station to the UE using RRC signals. *See* Ground 2, [1.2].

169. The dependent claims largely recite minor ancillary features that are not tied to the specific disclosures and analysis of the independent claims.

170. Thus, the analysis for dependent claims 2-7 (which are effectively identical to 9-14 and 16-20) is the same for each of Ground 1 and 2. Therefore, I have presented the analysis for the dependent claims for both Ground 1 and Ground 2 because that subsequent analysis (for the dependent claims) is not dependent upon which reference is used as the primary reference.

171. Grounds 3 and 4 add references (3GPP36-213 and 3GPP36-212) that expressly disclose a "table" implementing resource allocations. Thus, if PO argues patentability based upon the data structure implementing a "table,"

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a POSITA would recognize that it would be obvious to implement the sets of patterns in Gao and You using the known data structure of a resource allocation table that was already used in the 3GPP standards (e.g., 3GPP36-213 and 3GPP36-212).

172. Ground 5 addresses claims 5, 12, and 19 which recite known aspects of numerologies based on subcarrier spacings. R1-1610129 describes in far greater detail these numerologies than the sparse disclosure in the '272 patent – which appears to merely regurgitate materials that had already been discussed in the 3GPP working groups in meetings such as RAN1#86-Bis.

A. Ground 1: The Challenged Claims Are Obvious Over Gao Combined with You.

173. As detailed below, Gao in combination with You discloses, or renders obvious, all Challenged Claims.[3]

174. Gao provides extensive detail regarding allocation on an OFDM symbol level as detailed below and in my general description of Gao above. You provides supplemental teachings that a POSITA would have

[3] As used herein, "discloses" includes that the reference's disclosure renders obvious to a POSITA.

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recognized would be beneficially applied to Gao's teachings. Such teachings include confirmation that resource patterns may be transmitted using RRC and confirmation that resource patterns may be indexed by bits in the DCI.

175. [This paragraph left intentionally blank].

1. A POSITA Would Have Been Motivated To Combine Gao and You With A Reasonable Expectation Of Success.

176. A POSITA would be motivated to combine Gao and You (regardless of which is considered the primary reference) with a reasonable expectation of success.

177. The technology and teachings of Gao and You heavily overlap as detailed in Grounds 1 and 2 and in the descriptions above. For example, both references teach a base station that performs resource allocation to specify resource for wireless transmissions to/from a UE on a PDSCH (from BS to UE) and PUSCH (from UE to BS).

178. Both references teach communicating the allocations in various formats to the UE including directly through the DCI and indirectly using resource allocation patterns as detailed in the Grounds below. Both references teach using resource "patterns" to communicate the specific OFDM symbols in the resource allocations through "regions" of allocated symbols. Both

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inventions come in the same time frame, and are concerned with technical matter being discussed in the RAN group in 3GPP around that time. This overlap and the disclosure are detailed in the Grounds below.

179. Gao and You each provide to each other additional implementation details regarding the "patterns" that are described less explicitly in the other reference that a POSITA would recognize as being beneficial to the implementation of the resource patterns described in the other reference.

180. For example, Gao explicitly describes that each pattern contains an OFDM symbol location and length. You's patterns are "regions" which logically have a starting OFDM symbol location and length (in time domain). A region of resources, as detailed in my discussion above regarding You, is recognized effectively as a two-dimensional region in which one dimension is time-domain as defined by OFDM symbols and the other dimension is frequency domain as defined by frequencies (or subcarriers).

181. You benefits from Gao's express statement of the pattern format containing the information (location and length) that define You's regions in the OFDM symbol extent. Because both references expressly teach that such time-domain allocations will be at a more granular level than the

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subframe level known in LTE, a POSITA would recognize that the region information must include the extents of the region which would be defined by a starting OFDM symbol and a number of symbols after the OFDM symbols corresponding to the time-domain dimension of the defined region.

182. Similarly, Gao teaches that one of the patterns is indicated by the DCI as detailed below in the discussion of "configuration signaling." You expressly details a specific field (the DCI RA field bits) that is used to select the pattern index of the particular pattern used for resource allocation. Grounds 1, 2 at [1.4]. A POSITA would recognize that You provides an efficient specific implementation of selecting the pattern by using specific DCI bits (e.g., the RA field) because You describes a basis for using such bits including to save space in the DCI and efficiently index a number of patterns using the DCI RA field bits.

183. Furthermore, when considering Gao (or You), a POSITA would be motivated to consider the teachings of other participants in the relevant 3GPP NR working groups, including those participants that made contributions as reflected in R1-1610129.

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184. As noted above, the owners of Gao and You (CATT and LG) were both contributing to the emerging RAN1 working groups as part of an industry effort to develop new 5G radio technologies ("NR").

185. These participants were working toward a common goal of interoperability using complementary techniques, concepts, and terminology. For Gao and You, given the heavy overlap in terminology (e.g., "regions" within "patterns" allocating OFDM symbols in a time-domain), a POSITA would recognize that each reference provides specific implementations that can be advantageously applied to the teachings of the other reference.

186. A POSITA would be confident in success of the combination as each reference (Gao and You) supplies known techniques for implementation of "patterns" to perform resource allocation — techniques being used for their known and intended purposes. The patterns provide pre-defined and pre-configured resource allocation information that can be efficiently indexed and specified by bits in the downlink control information.

187. Gao and You are also analogous art to the claimed invention and to each other, being in the same field of network communications. Gao and You derive from the same 3GPP working groups that the '272 patent cites

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as having "discussions" regarding the claimed invention as I have discussed herein.

188. Further, the combination (and both references) are directed to the same problem as the '272 patent – allocating resources at a more granular level in a 5G system than were allocated in the 4G system such as at the OFDM symbol level.

189. Gao and You each describe a similar solution to this problem – using sets of "patterns" from which individual resource allocation patterns are selected and identified by an index in the DCI information sent from the BS to the UE to efficiently index the patterns.

190. [This paragraph left intentionally blank].

2. The Challenged Claims Are Obvious Over The Proposed Combination.

a) Claim 1

1. A base station, comprising: a transceiver; a receiver; and a controller which controls the transceiver and receiver thereby performing operations including:

191. Gao teaches an eNB which a POSITA would recognize as referring to an eNodeB and which a POSITA would recognize as a "***base station.***" Notably, the '272 patent states that such an eNB is a base station.

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> The wireless communication system includes a user equipment (UE) and a base station (BS, eNB, gNB, or xNB) …
>
> The base station or a cell generally refers to a station communicating with the UE. The base station or the cell is a generic term referring to, but not limited to, all of various communication service areas and devices, such as a Node-B, an evolved Node-B (eNB), a gNode-B (gNB), a low power node (LPN), a sector, a site, various types of antennas, a base transceiver system (BTS), an access point, a point (e.g., a transmitting point, a receiving point, or a transceiving point), a relay node, a megacell, a macrocell, a microcell, a picocell, a femtocell, a remote radio head (RRH), a radio unit (RU), and a small cell.

192. EX-1001, 3:45-65.

193. Gao's eNB includes a transceiver ("***transceiver and receiver***") that is controlled by a processor ("***controller***") as depicted in Fig. 22 below.

194. Notably, the '272 patent does not, in fact, use the word "transceiver" at all. Instead, the '272 patent describes the following:

> Referring to FIG. 9, a base station 900 according to another embodiment includes a controller 910, a transmitter 920, and a receiver 930.

195. EX-1001, 18:19-21; Fig. 9.

196. A POSITA would recognize that the claimed transceiver (to the extent this is not just a mistake that should be transmitter as per the specification) would be, at a minimum, discloses and/or rendered obvious by Gao. Gao

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discloses a "transceiver" which a POSITA would recognize as a transmitter/receiver and thus it discloses both a "transceiver" and a "receiver" as the Challenged Claims.

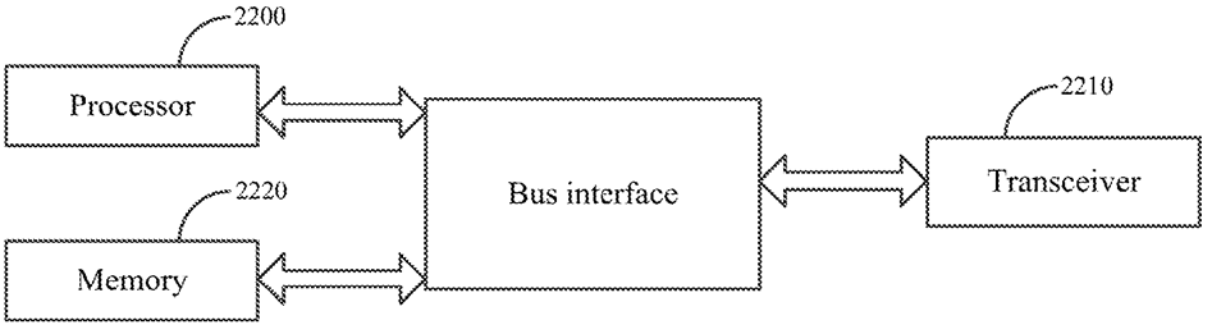

Fig. 22

197. EX-1007, Fig. 22.

198. Gao succinctly describes many of the claimed aspects including the transmission of resource allocation information using configuration signaling under the control of the processor/controller.

[0222] FIG. 22 is an eNB … the eNB includes: a processor 2200 configured …to allocate DL regions in a time unit, where the time unit includes at least two DL regions; and a transceiver 2210 configured to receive and transmit data under the control of the processor 2200 to notify a UE of the allocated DL regions via configuration signaling.

[0223] In an implementation, the transceiver is configured to notify the UE of the allocated DL regions via the configuration signaling by: notifying the UE of lengths and positions of the DL regions in the time unit; or notifying the UE of one of a plurality of predefined patterns,

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where each pattern includes an allocation of lengths and positions of the DL regions in the time unit; or notifying the UE of start or end positions of the DL regions in the time unit.

[0224] In an implementation, the processor is further configured to notify the UE, through the transceiver, of the UL region(s) and/or the GP region(s) in the time unit via the configuration signaling by: notifying the UE of the length(s) and the position(s) of the UL region(s) in the time unit through the transceiver; or notifying the UE of one of a predefined patterns through the transceiver, where each pattern includes an allocation of the length(s) and the position(s) of the UL region(s) in the time unit; or notifying the UE of the start or end position(s) of the UL region(s) in the time unit through the transceiver; or notifying the UE of indication information through the transceiver so that the UE determines the UL region(s) in the time unit according to the indication information under a predefined rule.

199. EX-1007, 0222-0224.

200. Thus, Gao discloses these elements.

201. [This paragraph left intentionally blank].

[1.1] transmitting, to a wireless device, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource, wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols,

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202. Gao discloses this element.

203. Gao's eNB "***transmit[s]… a RRC signal***" that include "a plurality of patterns of combinations of the sizes and the positions of DL regions [and] an uplink region…" to the UE ("***information on one or more allocations of a time-domain resource***").

> [0151] The UE can be notified directly of the size and the position of each DL region, and the size of the UL region can be determined implicitly according to whether there is a demand for feedback or uplink transmission; or the UE can be notified of the size and the position of each DL region, and the size and the position of the UL region, or can be notified of the size and the position of each DL region, and the size and the position of the GP; or the UE can be notified of the size and the position of the UL region, and the size and the position of the GP. Of course, alternatively a plurality of patterns of combinations of the sizes and the positions of DL regions, an UL region, and a GP region in a time unit can be predefined, and one of the patterns can be indicated via signaling.

204. EX-1007, 0151. The RRC signal (and patterns / regions) reflect allocated / configured time-domain resources for the "uplink shared channel" (PUSCH) and "downlink shared channel" (PDSCH). *E.g.*, EX-1004, 0148-0161.

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205. Gao discloses that "each pattern includes an allocation of lengths and positions of the [DL/UL] regions in the time unit." EX-1007, 0011-0012, 0021-0022. *See also* EX-1007, 0031-0032, 0041-0042, 0051-0052, 0061-0062, 0095, 0106-0111, 0191-0192, 0206-0207, 0223-0224, 0239-0240 (collectively "Gao Pattern Citations"), claims 1-2 (patterns with a length and start position of the region); Figs. 4-19 (all showing allocated regions within time units).

206. Gao's "allocating module" may perform the claimed allocation of regions within time units specifying the OFDM symbols which define the regions.

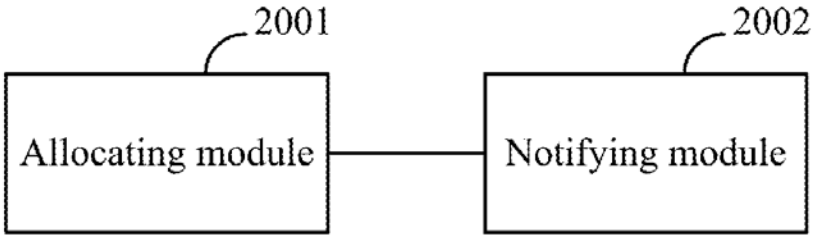

Fig. 20

207. EX-1007, Fig. 20,

FIG. 20 is a schematic structural diagram of an apparatus for transmitting data at the eNB side according to an embodiment of the invention, and as illustrated, the apparatus can include: an allocating module 2001 configured to allocate DL regions in a time unit, where the time unit includes at least two DL regions; and a notifying module

2002 configured to notify a UE of the allocated DL regions via configuration signaling.

208. EX-1007, 0190.

209. Gao's Fig. 2 depicts the allocation.

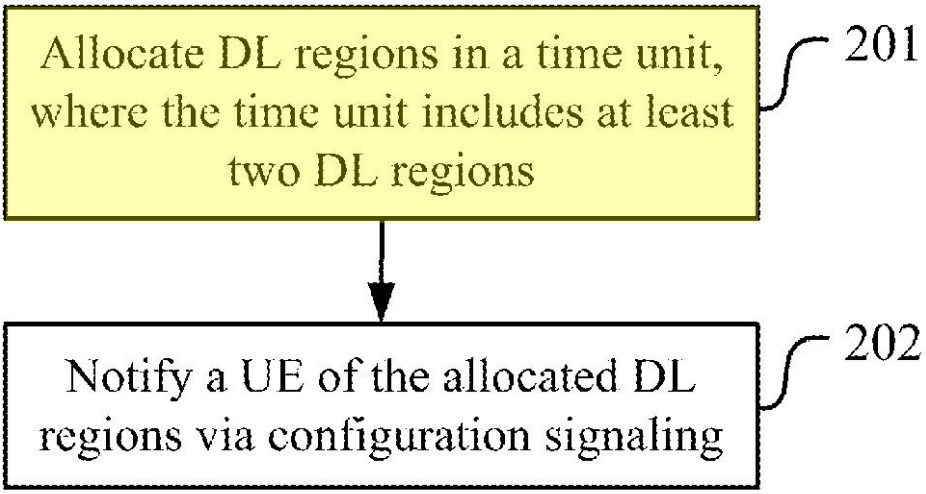

Fig. 2

210. EX-1007, Fig. 2,

[0099] FIG. 2 is a schematic flow chart of a method for transmitting data at the eNB side according to an embodiment of the invention, and as illustrated, the method can include the following operations.

[0100] The operation 201 is to allocate DL regions in a time unit, where the time unit includes at least two DL regions.

[0101] The operation 202 is to notify a UE of the allocated DL regions via configuration signaling.

211. EX-1007, 0099-0101.

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212. Gao allocates "regions" within "time units." "[T]he time unit is one or more slots…." EX-1007, 0019, 0204. Figure 5 shows two "time units" each divided into multiple "regions" for downlink and uplink shared channels.

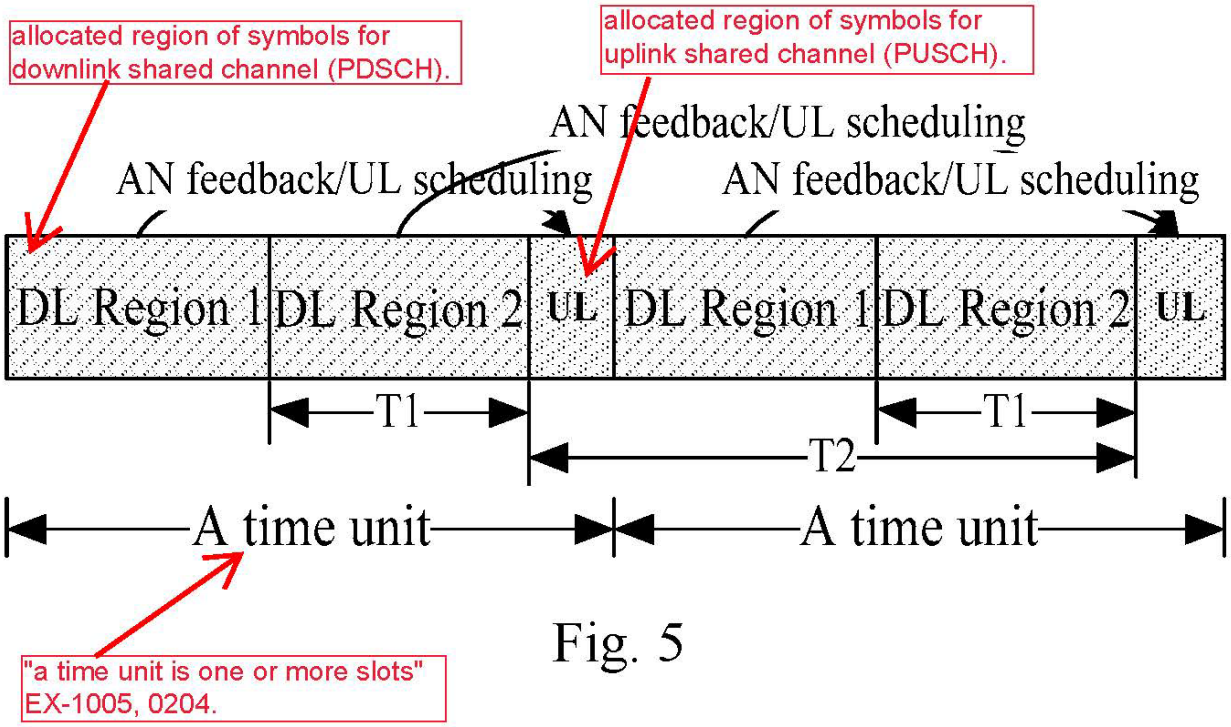

Fig. 5

213. EX-1007, Fig. 5.

214. Gao describes the details for these region allocations at length and the transmission of the information to the UE defining the regions so that the UE can determine which regions to decode and use for the different types of channels. EX-1007, 0147-0161. For example, Gao details the allocation

and scheduling between the different regions allocating resources in Figures 4-19:

215.

[0147] FIG. 4 is a schematic diagram of an allocation of and a correspondence relationship between uplink and downlink resources of a system with a TA and/or a switching period of time according to a first embodiment of the invention, and FIG. 5 is a schematic diagram of an allocation of and a correspondence relationship between uplink and downlink resources of a system without any TA and/or switching period of time according to the first embodiment of the invention. As illustrated in FIG. 4, for example, an eNB decides to divide a time unit into two DL regions and one UL region, and there is such a blank region or a GP region between a DL region and the UL region that is a reserved region determined to satisfy a Timing Advance (TA) demand of the UL, a switching period of time from the DL to the UL, etc., possibly taking into account interference between adjacent cells, and other factors. Of course, if a TA or a switching period of time or anti-interference is not required, then there may be no blank component or GP component as illustrated in FIG. 5. A correspondence relationship between the DL regions and the UL region can be predefined or configured directly, and for example, the first DL region in a time unit is predefined or configured to schedule uplink transmission in the UL region in the time unit (where uplink transmission in the UL region may occupy only a part of Orthogonal Frequency Division Multiplexing (OFDM) or Single-Carrier Frequency Division Multiple Access (SC-FDMA)

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symbols or a part of mini-slots in the UL region, so a plurality of uplink shared channels of the same or different UEs can be transmitted in a UL region in a Time Division Multiplexing (TDM) mode, or uplink transmission in the UL region may occupy the length of the entire UL region, and the same will apply hereinafter), the second DL region in a time unit is predefined or configured to schedule uplink transmission in the UL region in the next time unit, ACK/NACK for downlink transmission in the first DL region in a time unit (where downlink transmission in the DL region may occupy only a part of OFDM symbols or a part of mini-slots in the DL region, so a plurality of downlink transmission instances of the same or different UEs can be transmitted in a DL region in a TDM mode, or downlink transmission in the DL region may occupy the length of the entire DL region) is fed back in the UL region in the time unit (an uplink channel carrying ACK/NACK feedback information for downlink transmission may occupy only a part of OFDM or SC-OFDM symbols or a part of mini-slots in the UL region, so a plurality of uplink channels, carrying ACK/NACK, of the same or different UEs can be transmitted in a UL region in a TDM mode, or the uplink channel may occupy the length of the entire UL region, and the same will apply hereinafter), and ACK/NACK for downlink transmission in the second DL region in a time unit is fed back in the UL region in the next time unit, as illustrated in FIG. 4 and FIG. 5. Of course, alternatively the value of T can be predefined or configured, and an UL region spaced from a DL region by a period T of time after the DL region can be defined as a corresponding UL region, for the same effect of the correspondence

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> relationship predefined or configured as above, as illustrated in FIG. 4 and FIG. 5. The length of T may vary from one DL region to another, and the value of T for defining a scheduling relationship may or may not be the same as the value of T for defining a feedback relationship. When a time unit is divided differently into DL and UL regions, the corresponding value of T will also be different, and for example, there are different allocations of DL and UL regions for different services. In this embodiment, a time unit can be a slot or a sub-frame; or course, alternatively a time unit with another length can be defined.

216. EX-1007, 0147.

217. After allocation, Gao's eNB/BS notifies the UE of the allocation through different types of signaling. EX-1007, 0148-0153.

218. Gao's "regions" are (allocated) as, and include / identify, OFDM symbols ("***the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols***"). For example, Gao notes that, as part of its processing, the UE will need to "determine a resource." EX-1007, [0137] (control channel provides information for a "UE to determine a resource (e.g., a symbol or a mini-slot)"). This confirms that, if the "resource" is being "determined" at a "symbol" level, the resource allocation is being performed at that same symbol level because the resource allocation information provides the basis on which determination is performed.

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219. As a further example, Gao's eNB "indicates a time domain position of the UL region directly, e.g., the number of a symbol, a micro-slot, a slot, a sub-frame, etc., …." EX-1007, [0128]. This disclosure further confirms that, when Gao indicates a "position of" a region (such as in the patterns), that position can include the specification of an individual OFDM symbol as the start position of the region. At a minimum, this disclosure renders obvious that the starting position would be at an OFDM symbol as specified in the patterns and as reflected by the "number of a symbol" within the slot, mini-slot, or region being defined.

220. Gao's region resource allocation examples include that the "sizes of respective DL regions in a time unit may or may not be the same; and for example, there are two symbols in the first DL region, and three symbols in the second DL region." EX-1007, 0140. This is an express disclosure that the allocation of the region is at the symbol level in order to be able to specify the specific starting position of the region because such symbol level would be needed if the region can be different sizes, such as two or three symbols.

221. I quoted [0147] above. This paragraph teaches that the allocation is occurring at the OFDM symbol level because the "transmission in the DL

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[UL] region may occupy only a part of OFDM symbols or a part of mini-slots in the DL[UL] region…." If the transmission is occurring in only a portion (part) of the OFDM symbols, allocation information would be needed (or at a minimum obvious and beneficial and useful) to be able to determine which OFDM symbols are being used for the transmission.

222. As a further example, Gao specifies a second time that the allocated regions may only be a portion of the symbols in the time unit – thus requiring the allocation information to provide such information (or, at a minimum, rendering obvious the provision of such information at the symbol level to beneficially and efficiently use the available symbols). EX-1007, 0170.

223. Gao's eNB may transmit (which is part of configuring) the patterns with the allocated regions to the UE through higher-layer signaling such as RRC signals. "[T]he eNB can further pre-configure a DL region to be detected by the UE, and this configuration can be made semi-statically via Radio Resource Control (RRC) signaling…." EX-1007, 0159, 0179.

224. A POSITA would understand Gao's reference to pre-configuring a downlink (DL) region to disclose transmitting the patterns that define each region using RRC signals. Gao contains extensive disclosure as described

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herein that the patterns provide for pre-configured resource allocation by specifying the position and length of the regions for the allocated symbol within the patterns. Thus, Gao discloses (and/or renders obvious) that the patterns are transmitted via RRC by disclosing that the regions (which are encompassed within the patterns) are transmitted by the RRC – including because Gao identifies specifying "one of" the patterns to define the regions and thus the patterns encompassing the regions must be associated with the region information. At a minimum, Gao renders obvious that the patterns (which are predefined) is encompassed in the pre-configuration of the regions and transmitted using the same type of signaling (e.g., RRC).

225. The claim language recites "wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols…" If PO asserts this language requires disclosure and identification of a resource with only a single OFDM symbol, Gao discloses (including rendering obvious) such single OFDM symbol resources based on the disclosure above.

226. Gao does not limit its disclosure to any particular sized region and includes embodiments of various sizes. Furthermore, Gao's Figures 4-19 each show regions of different sizes. A POSITA would understand that

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Gao's "region" can be any number of symbols (up to the slot-level as defined in Gao) because the purpose of Gao was to provide a more refined allocation at the level of specific OFDM symbols and a single symbol allocation falls within that more refined allocation and provides for the maximum beneficial usage of the technology within Gao used to allocate resources at a more granular level. Allocation at the individual OFDM symbol level would provide the system with the ability to maximize the goal of minimizing the latency in response time and allowing for more regions to be defined in a particular slot.

227. If PO argues that Gao does not expressly recite that the "plurality of patterns" is transmitted via RRC, such an implementation is obvious, particularly in light of You. As noted above, Gao expressly states that the "region" configuration is done using RRC. EX-1007, 0159. Because the regions are configured by the patterns, it is at least obvious that the patterns are transmitted using RRC for the reasons that I have mentioned above.

228. You describes such RRC configuration and transmission of patterns using RRC. You's resource allocation "patterns" indicate "regions" for the PDSCH (DL shared channel), and those patterns are transmitted via RRC. Ground 2, [1.1] (incorporated herein); EX-1004, 0222-0224. A POSITA

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would recognize that You provides an explicit description of an implementation of Gao using RRC to transmit the patterns containing the regions (which Gao states are transmitted via RRC) particularly in light of Gao already associating the regions as being defined within the pattern and Gao's discussion of pre-configuration of the regions using RRC as detailed above.

229. [This paragraph left intentionally blank].

[1.2] wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared channel (PDSCH) or a physical uplink shared channel (PUSCH), and;

230. Gao discloses this limitation for the reasons in [1.1] which detailed that Gao's allocations are for a number of OFDM symbols and correspond to PDSCH and PUSCH.

231. Gao's "regions" include symbols for PDSCH and PUSCH as shown in Figure 5.

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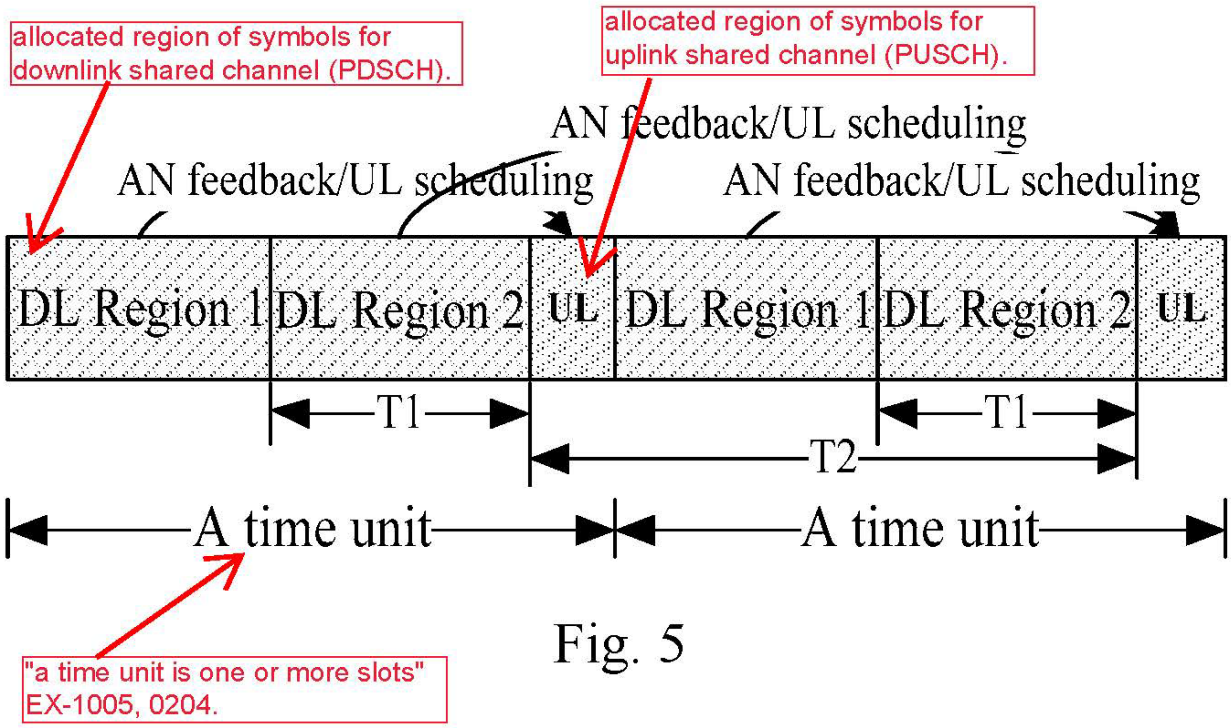

Fig. 5

232. EX-1007, Fig. 5, 0153 ("schedule the UE to receive a downlink shared channel in the selected DL region, or to transmit an uplink shared channel in a corresponding UL region"); Figs. 4-19.

233. The '272 patent references PDSCH and PUSCH as the "DL shared channel" and "UL shared channel." EX-1001, 6:15-25. Gao pervasively "determines" the symbols for a "downlink shared channel" and/or a "uplink shared channel" identified by "regions" as detailed in [1.1].

234. For example, Gao teaches:

[0153] The eNB to schedule the UE selects at least one DL region in a time unit, and transmits a downlink control channel to the UE in a downlink control channel search space of the selected DL region to

> schedule the UE to receive a downlink shared channel in the selected DL region, or to transmit an uplink shared channel in a corresponding UL region.
>
> [0154] For example, in a first scenario, the eNB transmits a downlink control channel 1 in a downlink DCI format in a DL region 1 to schedule a UE 1 to receive *a downlink shared channel 1 in the DL region 1*, and transmits a downlink control channel 2 in the downlink DCI format in a DL region 2 to schedule a UE 2 to receive a downlink shared channel 2 in the DL region 2.
>
> [0155] In another example, in a second scenario, the eNB transmits a downlink control channel 1-1 in a downlink DCI format in a DL region 1 to schedule a UE 1 to receive a downlink shared channel 1-1 in the DL region 1, transmits a downlink control channel 2-1 in the downlink DCI format in the DL region 1 to schedule a UE 2 to receive a downlink shared channel 2-1 in the DL region 1, transmits a downlink control channel 1-2 in the downlink DCI format in a DL region 2 to schedule the UE 1 to receive a downlink shared channel 1-2 in the DL region 2, and transmits a downlink control channel 2-2 in the downlink DCI format in the DL region 2 to schedule the UE 2 to receive a downlink shared channel 2-2 in the DL region 2.

235. EX-1007, 0153-0155.

236. The “determined” number of symbols is the number of symbols in the “regions” specified by the “patterns” for the specified channel as detailed in 1.1

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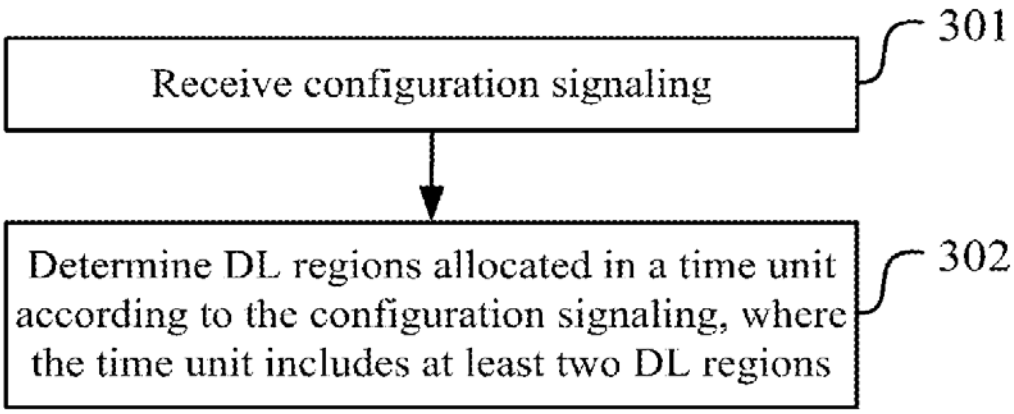

Fig. 3

237. EX-1007, Fig. 3, 0104, 0109, 0130, 0152, 0172, 0180, 0192-0220.

238. Gao's UE "determine[s] the DL regions allocated … by: determining one of a plurality of predefined patterns according to the configuration signaling, where each pattern includes an allocation of lengths and positions of the DL regions in the time unit…." EX-1007, 0206.

239. Gao discloses a "determining module" that may perform the claimed determination:

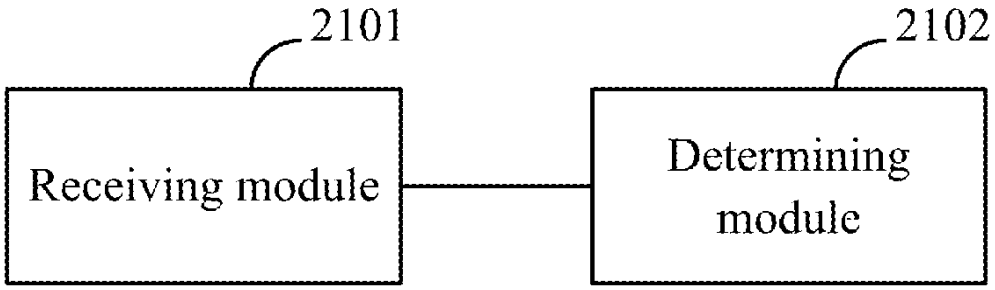

Fig. 21

240. EX-1007, Fig. 21; 0205-0209. Gao's "detecting module" also performs the claimed determining which it detects and decodes the information allocating the symbols and then uses that information to detect and decode the DL regions and the individual symbols therein.

[0210] In an implementation, the apparatus further includes: a detecting module configured to detect each DL region or each detection DL region in a time unit for a downlink control channel.

[0211] In an implementation, before each detection DL region in the time unit is detected for the downlink control channel, the detecting module is further configured to: receive configuration information, and determine a detection DL region in the time unit according to the configuration information, or determine a detection DL region in the time unit according to a pre-definition, where the detection DL region can be a part or all of the DL regions in the time unit.

[0212] In an implementation, the detecting module is further configured, when a downlink DCI format is used for the downlink control channel, to transmit ACK/NACK feedback for the downlink control channel, and/or ACK/NACK feedback for a downlink shared channel corresponding to the downlink control channel, in a UL region corresponding to a DL region in which the downlink control channel is received; or when an uplink DCI format is used for the downlink control channel, to transmit an uplink shared channel corresponding to the downlink control channel in a UL region corresponding to a DL region in which the downlink control channel is received.

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241. EX-1007, 0210-0212.

242. [This paragraph left intentionally blank].

[1.3] wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and;

243. Gao discloses this element.

244. As detailed in [1.1], Gao's "time unit is one or more slots" and may include multiple "regions" with OFDM symbols. EX-1007, 0149, 0204, 0219. Thus, the "regions" must be at least ***smaller than or equal to the number of OFDM symbols included in a slot*** because each region is shown as being encompassed in a single slot. Therefore, the determined number of OFDM symbols for the specific region must be no greater than (less than or equal to) the number of OFDM symbols in the slot.

245. Furthermore, according to the '272 patent "a slot may be formed of 14 symbols." EX-1001, 7:7. As identified in 1.1, Gao teaches regions including 1, 2 or 3 symbols – which is "***smaller than … a number of OFDM symbols included in a slot***." EX-1007, 0140. Gao's regions may include OFDM "symbols" or "mini-slots" which meet this element also

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because the individual symbols are less than, or equal to the number of symbols in a slot. EX-1007, 0147.

246. [This paragraph left intentionally blank].

[1.4] transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string,

[1.5] wherein the bit string in the field relates to a row index of an allocation table, and

[1.6] wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot.

247. Gao's usage of "patterns" discloses (at a minimum, renders obvious) these inter-related elements reciting the format of the allocation transmission to the UE.

248. In these claim elements, the DCI includes bits that "relate to" a row index into a "table" that includes information on a "starting OFDM symbol" and "the number of the OFDM symbols." While the '272 patent does not articulate any criteria to determine what is a "table" for the claims, at a

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minimum, Gao's patterns render obvious the implementation of the claimed "table" under any reasonable interpretation as detailed below.

249. As I have noted in the discussion of "tables" in the Scope and Content of the Prior Art above (incorporated herein), tables are a pervasively understood concept. Many patents identify tables in their specification and many references, such as 3GPP36.212, and 3GPP36.213 include the concept of data structures and/or representations of related data in forms recognized as tables.

250. Gao's description of the patterns, the content of the patterns, and how the patterns are specified at a minimum renders obvious the usage of tables, a bit string, and a row index of a table with the claimed content as detailed below.

251. As I discussed above in the description of Gao in the Scope and Content of the Prior Art, Gao's "DCI" includes "configuration signaling" ("***bit string***") that identifies "one of a plurality of predefined patterns" (rendering obvious "***relates to a row index of an allocation table***") "wherein each of the plurality of patterns includes an allocation of lengths and positions of the DL regions" (rendering obvious an "***allocation table includes information on a starting OFDM symbol and the number of the OFDM***

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symbols") wherein each "region" is "***smaller than or equal to the number of OFDM symbols included in the slot***" (detailed in [1.3]). *E.g.*, EX-1007, 0011-0012, 0191-0192.

252. First, Gao's BS uses DCI to communicate the specific pattern to the UE through "configuration signaling."

> the notifying module is configured to notify the UE of the allocated DL regions **via the configuration signaling** by: … notifying the UE of one of a plurality of predefined patterns, where each pattern includes an allocation of lengths and positions of the DL regions in the time unit; …

253. EX-1007, 0191. By notifying "one of a plurality of predefined patterns" the configuration signaling renders obvious that the configuration signaling is specifying an index into the predefined patterns. An index is generally understood to allow a the identification of a particular one out of a group – in this case, a particular one pattern out of the group of the predefined patterns.

254. Gao's "notifying module" may perform configuration signaling.

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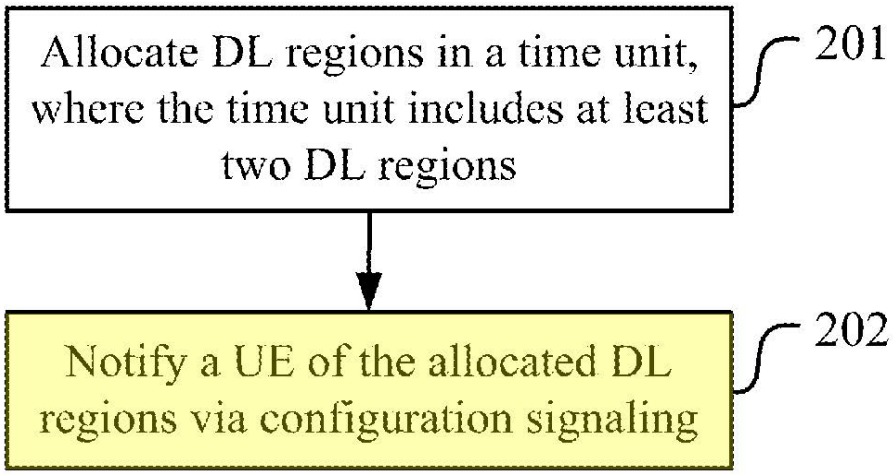

Fig. 2

255. EX-1007, Fig. 2.

256. Gao repeatedly identifies that the configuration signaling will be used to identify one of the patterns. EX-1007, 0223-0224, 0011-0012, 0031-0032, 0051-0052, 0106-0107. In Gao, "one of the patterns can be indicated **via signaling**" from "a plurality of patterns of combinations of the sizes and the positions of DL regions, an UL region, and a GP region in a time unit [that are] predefined." EX-1007, 0151. This teaches that the configuration signaling is an index as articulated above.

257. Gao's "configuration signaling" may be transmitted in the "Downlink Control Information (DCI)" to the UE: "the configuration signaling … can be transmitted in a control channel (e.g., in a preset Downlink Control

Information (DCI) format…)" EX-1007, 0150. *See also* EX-1007, 0024 ("downlink control signaling"); 0209, 0151,

258. Scheduling transmissions also includes identification of the pattern with its associated region(s).

> [0153] The eNB to schedule the UE selects at least one DL region in a time unit, and transmits a downlink control channel to the UE in a downlink control channel search space of the selected DL region to schedule the UE to receive a downlink shared channel in the selected DL region, or to transmit an uplink shared channel in a corresponding UL region.
>
> [0154] For example, in a first scenario, the eNB transmits a downlink control channel 1 in a downlink DCI format in a DL region 1 to schedule a UE 1 to receive a downlink shared channel 1 in the DL region 1, and transmits a downlink control channel 2 in the downlink DCI format in a DL region 2 to schedule a UE 2 to receive a downlink shared channel 2 in the DL region 2.
>
> [0155] In another example, in a second scenario, the eNB transmits a downlink control channel 1-1 in a downlink DCI format in a DL region 1 to schedule a UE 1 to receive a downlink shared channel 1-1 in the DL region 1, transmits a downlink control channel 2-1 in the downlink DCI format in the DL region 1 to schedule a UE 2 to receive a downlink shared channel 2-1 in the DL region 1, transmits a downlink control channel 1-2 in the downlink DCI format in a DL region 2 to schedule the UE 1 to receive a downlink shared channel 1-2 in the DL region 2,

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> and transmits a downlink control channel 2-2 in the downlink DCI format in the DL region 2 to schedule the UE 2 to receive a downlink shared channel 2-2 in the DL region 2.
>
> [0156] In another example, in a third scenario, the eNB transmits a downlink control channel 1 in an uplink DCI format in a DL region 1 to schedule a UE 1 to transmit an uplink shared channel 1 in the UL region in the time unit, and transmits a downlink control channel 2 in the uplink DCI format in a DL region 2 to schedule a UE 2 to transmit an uplink shared channel 2 in the UL region in the next time unit.

259. EX-1007, 0153-0156. "Scheduling" a transmission encompasses providing the information necessary to identify how to receive that transmission. In the context of Gao (e.g., as shown in the quotes above), to provide the information in the DCI to "schedule" the transmission is providing the necessary information in the DCI for the UE to be able to properly receive the transmission. That is the purpose of the DCI entries above – to provide control information to allow the UE to receive the transmission (e.g., of the downlink shared channel) or to be able to transmit the uplink shared channel in a fashion that it will be received properly by the BS.

260. The "configuration signaling" within DCI allows the UE to detect / determine the DL and uplink (UL) regions using the patterns. EX-1007, 0170.

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261.

[0206] In an implementation, the determining module is configured to determine the DL regions allocated in the time unit according to the configuration signaling by: determining lengths and positions of the DL regions in the time unit according to the configuration signaling; or determining one of a plurality of predefined patterns according to the configuration signaling, where each pattern includes an allocation of lengths and positions of the DL regions in the time unit; or determining start or end positions of the DL regions in the time unit according to the configuration signaling.

[0207] In an implementation, the determining module is further configured to: determine the UL region(s) and/or the GP region(s) in the time unit according to the configuration signaling, where: the length(s) and the position(s) of the UL region(s) in the time unit is or are notified via the configuration signaling; or one of a predefined patterns is notified via the configuration signaling, where each pattern includes an allocation of the length(s) and the position(s) of the UL region(s) in the time unit; or the start or end position(s) of the UL region(s) in the time unit is or are notified via the configuration signaling; or indication information is notified via the configuration signaling so that the UE determines the UL region(s) in the time unit according to the indication information under a predefined rule.

[0208] In an implementation, the determining module is further configured to: determine the UL region(s) in the time unit according to uplink scheduling signaling, or determine the UL region(s) in the time

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> unit according to a position at which ACK/NACK for downlink transmission is fed back.
>
> [0209] In an implementation, the receiving module is further configured to receive the configuration signaling transmitted via higher-layer signaling or physical downlink control signaling in a unicast or broadcast or multicast form.
>
> [0210] In an implementation, the apparatus further includes: a detecting module configured to detect each DL region or each detection DL region in a time unit for a downlink control channel.
>
> [0211] In an implementation, before each detection DL region in the time unit is detected for the downlink control channel, the detecting module is further configured to: receive configuration information, and determine a detection DL region in the time unit according to the configuration information, or determine a detection DL region in the time unit according to a pre-definition, where the detection DL region can be a part or all of the DL regions in the time unit.

262. EX-1007, 0206-0211. In the passages above, the configuration signaling (which can be in the DCI as detailed above), notifies the UE of the selected / allocated patterns to allow the UE to determine and detect the associated regions for the downlink shared channel and to transmit in the regions for the uplink shared channel.

263. Gao's DCI provides the "configuration signaling" to "schedule a UE [] to receive a downlink shared channel" in various "DL regions" and "UL

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regions." EX-1007, 0154-0158; 0160-0167; 0173-0185, 0239-0240. As detailed above, scheduling a channel in this context encompasses that the configuration signaling is providing the needed information for the UE to understand and use the specific selected patterns – in this case, by providing the "one of" those patterns which, at a minimum, renders obvious that the "one of" in the configuration signaling / DCI is an index into the set of patterns.

264. This "configuration" includes that the DCI specifies an index into a collection of resource patterns that were discussed in 1.1. A POSITA would recognize that it would be obvious to implement Gao's "plurality of predefined patterns" as an "allocation table" and that the DCI information used by Gao to identify "one of" the patterns provides an index into those patterns.

265. The patterns constitute a set of data collections in which the purpose of the set is to allow for pre-configuration and then selection of one of the set.

266. I discussed in the background section the known formats of DCI information including those formats shown in 3GPP36-212 at section 5.3.3.1 These formats show that the DCI was known by a POSITA to include, and / or render obvious, a collection of fields in a computer data

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structure. In light of this known information regarding DCI (which has been used in wireless standards for more than a decade prior to the Priority Date), a POSITA would have understood the entries in the DCI, including Gao's configuration signaling to be bit strings as claimed or at a minimum, render obvious such bit strings. They are individual bits that are grouped together in defined fields. These groupings reflect, or render obvious, that the grouped bits are a bit string. The '272 patent does not articulate any specific requirement for a "bit string" and, indeed, does not even mention the term "string" in the specification, much less "bit string."

267. The following example uses Gao's teaching for the downlink (DL) shared channel (PDSCH). The same analysis applies to Gao's uplink (UL) shared channel (PUSCH). Gao identifies that there is a "plurality predefined pattern" and "each pattern includes an allocation of the length(s) and the position(s) of the DL region(s) in the time unit." EX-1007, 0011, 0191.

268. Gao's "plurality of predefined patterns" are illustrated in the example using Fig. 6 below. In Figure 6, "DL Region 1" appears slightly larger than "DL Region 2" although I understand that patent figures are not necessarily drawn to scale. However, using Gao's example of "two symbols in [one]

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DL region, and three symbols in [a different] DL region" (EX-1004, 0140), the pattern implementation using a table (top left) would have a "plurality of predefined patterns, where each pattern includes an allocation of lengths and positions of the DL regions." Thus, for example, Gao would have, *e.g.*, patterns 0 to 15 as shown below with each pattern including the location (start) and length of a DL region:

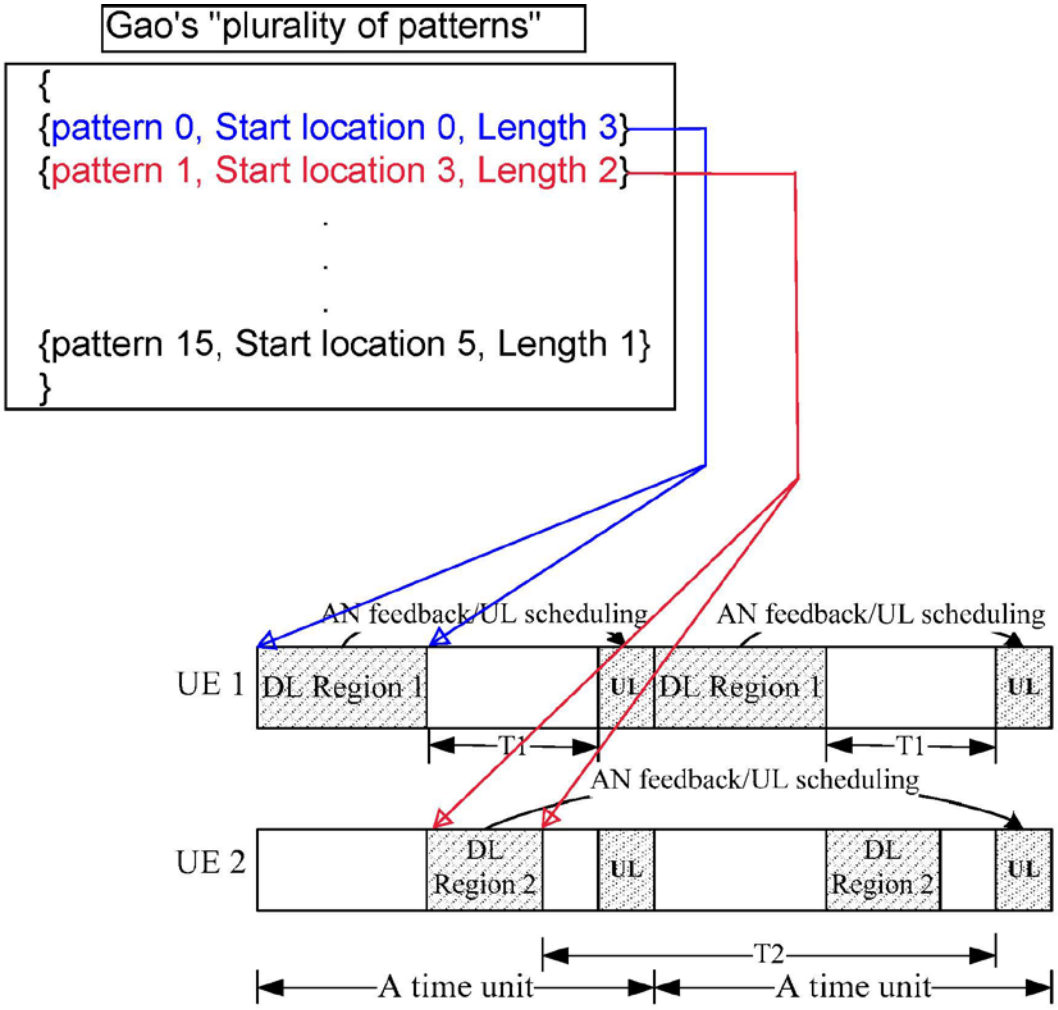

Fig. 6

269. In this example, pattern 0 starts at symbol location (position) 0 and has a symbol length of 3 symbols. Pattern 1 starts at symbol location (position) 3 and has a symbol length of 2 symbols. As shown above, the red arrows and blue arrows show how the information within the plurality of patterns (as implemented by a table shown above) provides the starting position and length / number of OFDM symbols for each region that is allocated.

270. Any of Gao's Figures 4-19 would provide a similar example of different patterns defining the region's start position and length. Each of those Figures show similar "time units" that include one or more regions representing OFDM symbols (at a start and length) within the time unit.

271. Moreover, the "plurality of predefined patterns" could include each of the various patterns shown in Figures 4-19 or some subset of those exemplary patterns or other patterns. Gao does not limit the specific patterns to only those disclosed, but rather these are examples of patterns that can be defined in the overall set of patterns.

272. Gao's "pattern" might indicate multiple "regions." In such an embodiment, the set of patterns would reflect the multi-region patterns. *E.g.*, EX-1007, Figs. 4-19. Using multiple regions within one pattern does not impact the invalidity analysis. First, the claims do not exclude such a

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situation and requirement merely that at least one allocation be selected. Thus, the claims do not expressly exclude an arrangement in which the specific pattern includes multiple allocations regions – such as a separate allocation DL region for different UEs. With a multi-region pattern, each pattern would include an indication (explicit or implicit) of the regions and their location / lengths and allow for specification of one or more regions within the pattern.

273. It would be obvious also to implement such a multi-region pattern by using multiple individual patterns that each contain a single region. Gao does not limit or exclude the format of the patterns and the Challenged Claims do not exclude any such particular implementation of patterns as reflected in table format.

274. As detailed above, Gao uses DCI "configuration signaling" to "notify[] the UE of one of [the] plurality of predefined patterns…" EX-1007, 0191-0192, 0206-0207, 0224, 0240, 0110.

275. Pictorially, such DCI configuration signaling would appear like:

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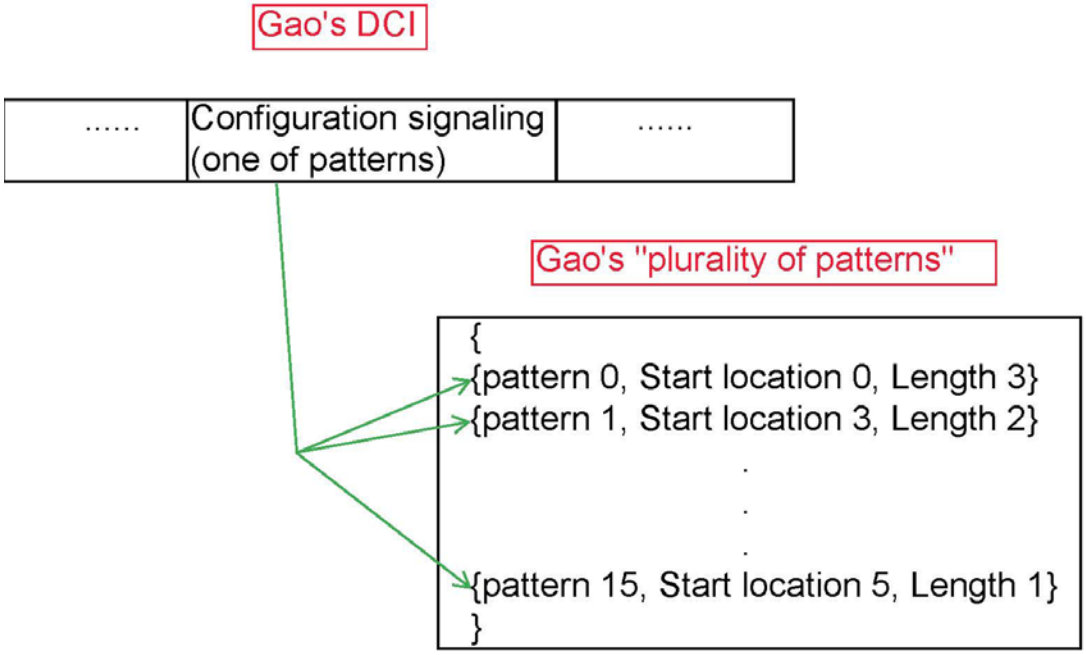

276. The field within the DCI is implemented with bits (as discussed above) and, as detailed above, Gao teaches the selection of "one of" the predefined patterns using the DCI configuration signaling. In this example, the DCI provides a bit string that serves as an index to select one of the patterns as shown in the green arrows.

277. While Gao does not explicitly use the term "table" or "index," Gao renders obvious such an implementation.

278. Gao's patterns have an "index" (either implicitly or explicitly) because Gao repeatedly describes the ability to specify "one of" the patterns in the DCI. At a minimum, it would be necessary and/or obvious to include such an index to allow for selection of one of the patterns out of the set of

predefined patterns. EX-1007, 0192, 0207, 0224, 0240, 0110. The '272 patent does not articulate specifically any requirements for an index that would lead a POSITA to reject the obvious implementation of the patterns as a table in which the specific data sets (rows) are selected by use of an index specifying that "one of" the set.

279. Gao's "plurality of patterns" at least renders obvious a table implementation as claimed. As detailed in the discussion of tables in the Scope and Content of the Prior Art, a POSITA would understand a "table" in the context of the '272 patent to be rendered obvious by a data structure implementing an organized grouping of data that can be accessed by identifying one of the groupings through, for example, an index that is specified either implicitly or explicitly.

280. Gao's "predefined patterns" render obvious such a table data structure implementation. In Gao, "each pattern includes an allocation of lengths and positions of the [DL/UL] regions in the time unit." EX-1007, 0191-0192 (and citations above). This is a set of related information in which each element of the grouping/set can identify a particular set of data entries (e.g., the regions being allocated and the position/length of those regions).

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281. Gao's patterns each correspond to a table row identified by the "configuration signaling" index for the particular groupings for different time units so that the specific desired information for a particular pattern (including the regions defined therein) can be identified.

282. Furthermore, Gao's patterns render obvious "***allocation tables***" as claimed because, as noted above, the patterns reflect the "allocation" of resources (*e.g.*, regions of OFDM symbols) for a particular "time unit." This is discussed in detail in 1.1-1.3 in which I describe how the patterns specify the regions that are allocated and which are comprised of OFDM symbols in the time domain.

283. Gao's patterns "***include[] information on a starting OFDM symbol and the number of the OFDM symbols***" as claimed because "each pattern includes an allocation of lengths and positions of the [DL/UL] regions." *E.g.*, EX-1007, 0011-0012; Gao's Pattern Citations. Gao's "position" for each region is "information on a starting OFDM symbol" because it identifies the OFDM symbol on which that region starts. EX-1007, 0128 ("a time domain position of the [] region" can be "the number of a symbol"); 0137. Gao's "length" of each region is "information on ... the number of the OFDM symbols" because it defines the length (in number of symbols)

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of that region. Moreover, a region being defined by a start and length is consistent with a 2-dimensional allocation of resources in which the time-domain is defined by a particular starting position of the first time-domain OFDM symbol and a length defining how many symbols are in the time-domain axis for that region.

284. Furthermore, consistent with a POSITA's understanding of Gao's "plurality of predefined patterns" rendering obvious a table implementation, a POSITA would understand that it would be obvious to implement resource allocation "patterns" as "tables" indexed by bits specified in a DCI as I have articulated in Grounds 3 and 4 below. The 3GPP standards already included "allocation tables" indexed by DCI bits. Such "patterns" were reflected in "tables" that are indexed by "bits" in a DCI. Such tables provide the benefit of a known data structure that can be efficiently indexed to be able to re-use data (the patterns) while minimizing the overall amount of transmissions because, for example, the tables can be transmitted during configuration and then the usage of the tables can be specified by a few bits during the repetitive transmission of setting up the parameters for allocating resources for the channels over time.

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285. Finally, as detailed in [1.3], Gao teaches that "regions" specified by "patterns" have "***smaller than or equal to the number of OFDM symbols included in the slot***." Each of the regions is shown as being encompassed within a single time unit which can be a single slot. Thus, Gao teaches that the allocation on a region basis specifies less than or equal to the number of symbols in that slot.

286. As I have explained above, a DCI is a data structure with fields comprised of bits. If PO argues that Gao does not explicitly recite "bits" or a "bit string" in the DCI to index the patterns, You discloses such an implementation for the reasons detailed in [1.6] of Ground 2. For example, You details a DCI with resource allocation (RA) field that has N bits used to index 2^N resource allocation patterns. EX-1004, 0222. A POSITA would recognize that You's "N bits" correspond to, and represent an implementation of, Gao's "configuration signaling" that is used as an index to identify one of the plurality of patterns and represents a bit string. You provides the motivation to use You's implementation in identifying that this implementation will "reduce the size of a resource allocation (RA) field of DCI" which a POSITA would recognize as desirable to increase the efficiency of the wireless system. Moreover, as I have noted above, the

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'272 patent does not use the terms "string" or "bit string" in its specification. The closest that the '272 patent comes to a bit string in its specification appears to be the discussion of an "information area (e.g., information area formed of 3 bits for indicating indexes 0 to 7 in the case of the Table 1, or formed of 4 bits for indicating indexes 0 to 15 in the case of the Table 2)." Gao's disclosure at a minimum renders obvious such a "information area formed of … bits" and therefore discloses this element in the context of the '272 specification.

287. [This paragraph left intentionally blank].

b) <u>Claims 8 and 15</u>

288. Claim 8 is substantively the same as claim 1 except that claim 8 is written from the perspective of the "wireless device" (*e.g.*, UE) that is receiving the transmissions from the "base station" in claim 1. EX-1001, 3:52-59.

289. Claim 15 is substantively the same as claim 8 describing the operation of a wireless devices that receiving information from a base station except that claim 15 is a method that recites the steps recited in claim 8 for the "controller." Thus, claims 8 and 15 are invalid for at least the same reasons as claim 1 as detailed in the analysis of the corresponding elements.

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290. For claims 8 and 15, the substantive analysis is in the corresponding element for claim 1. For example, elements 8.6 and 15.6 are disclosed for the reasons cited in element 1.6. The Claim Element Table above provides the element numbering.

291. Gao's "UE" is the claimed "wireless device" that receives the allocation information and also determines allocated symbols. EX-1007, Fig. 23, 0238-0253, claim 1. Gao's terminology ("UE") matches the '272 patent terminology. EX-1001, 4:40-53, 3:52-59.

292. [This paragraph left intentionally blank]

B. Ground 2: Claims 1-20 Are Invalid Over You alone or in combination with Gao

293. In this combination, You is the primary reference. Gao supplements You's teachings as noted in the elements below. Primarily, Gao provides an explicit teaching that each pattern in the set of patterns includes a location (start position) and length (number of symbols) for the allocated regions within the patterns.

294. The references (You and Gao) and the general motivations to combine are detailed in Ground 1 and incorporated herein.

a) Claim 1

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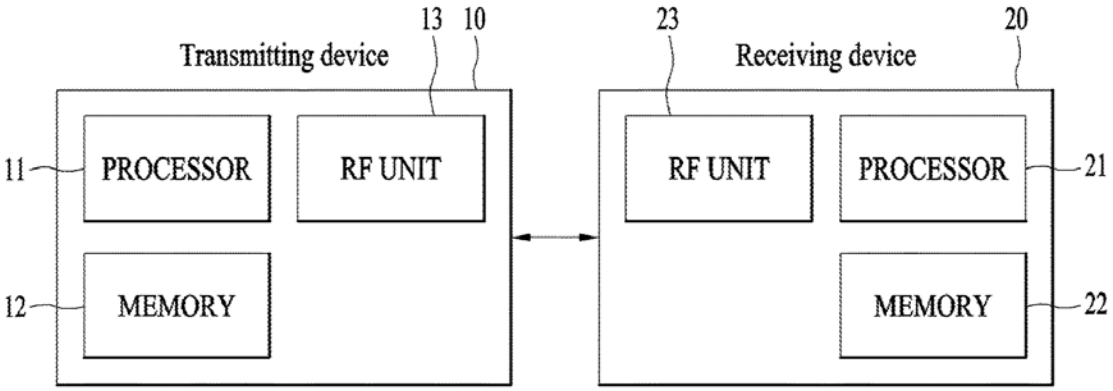
[1.0] A base station, comprising: a transceiver; a receiver; and a controller which controls the transceiver and receiver thereby performing operations including:

295. You discloses a transmitting device referenced as an "eNB" ("**base station**") that includes an RF unit ("**transceiver**" and "**receiver**") that is controlled by a processor ("**controller**") as depicted in Fig. 14. As I noted for Gao above, the '272 patent specifically identifies an "eNB" as a type of "base station." EX-1001, 1:60-2:49; 3:45-65.

FIG. 14



296. EX-1004, Fig. 14.

FIG. 14 is a block diagram illustrating elements of a transmitting device 10 and a receiving device 20 for implementing the present invention.

[0325] The transmitting device 10 and the receiving device 20 respectively include Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages, memories 12 and 22 for storing information related to communication in a wireless communication system, and processors 11 and 21 operationally connected to elements such as the RF units 13 and 23 and the memories 12 and 22 to control the elements and configured to control the memories 12 and 22 and/or the RF units 13 and 23 so that a corresponding device may perform at least one of the above-described embodiments of the present invention.

[0326] The memories 12 and 22 may store programs for processing and controlling the processors 11 and 21 and may temporarily store input/output information. The memories 12 and 22 may be used as buffers.

[0327] The processors 11 and 21 generally control the overall operation of various modules in the transmitting device and the receiving device. Especially, the processors 11 and 21 may perform various control functions to implement the present invention. The processors 11 and 21 may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The processors 11 and 21 may be implemented by hardware, firmware, software, or a combination thereof. In a hardware configuration, application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), or field programmable gate arrays (FPGAs) may be included in the processors 11 and 21. Meanwhile, if the present invention is implemented using firmware or software, the

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> firmware or software may be configured to include modules, procedures, functions, etc. performing the functions or operations of the present invention. Firmware or software configured to perform the present invention may be included in the processors 11 and 21 or stored in the memories 12 and 22 so as to be driven by the processors 11 and 21.

297. EX-1004, 0324-0327.

298. As detailed above, You's eNB "processors 11 and 21 generally control the overall operation … [and] may be referred to as controllers, microcontrollers…." EX-1004, 0327. The "Radio Frequency (RF) units 13 and 23 capable of transmitting and receiving radio signals carrying information, data, signals, and/or messages…" EX-1004, 0325

299. The transmission and reception of data between the base station and UE are described throughout You. E.g., EX-1004, 0327-0335 (describing operation of BS and UE to transmit/receive data). In downlink, the eNB transmits to the UE. In uplink, the eNB receives from the UE.

> In the embodiments of the present invention, a UE operates as the transmitting device 10 in UL and as the receiving device 20 in DL. In the embodiments of the present invention, an eNB operates as the receiving device 20 in UL and as the transmitting device 10 in DL. Hereinafter, a processor, an RF unit, and a memory included in the UE will be referred to as a UE processor, a UE RF unit, and a UE memory,

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respectively, and a processor, an RF unit, and a memory included in the eNB will be referred to as an eNB processor, an eNB RF unit, and an eNB memory, respectively.

300. EX-1004, 0331.

301. [This paragraph left intentionally blank].

[1.1] transmitting, to a wireless device, a radio resource control (RRC) signal including information on one or more allocations of a time-domain resource, wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols,

302. You discloses this element.

303. You's eNB transmits radio resource control (RRC) signals including "resource patterns" that are (and include) "***information on … allocations of time-domain resources***" for channels including sPDSCH which stands for "shortened PDSCH") EX-1004, 0038. The "shortened PDSCH" falls within the claimed PDSCH and, at a minimum, renders such a PDSCH obvious. The claims do not specify any particular requirements for a PDSCH that would exclude the sPDSCH.

304. You uses "configure" (or "configuration") to describe allocating resources and conveying allocations to a UE. The '272 patent uses

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"configure" (or variants) to describe resource allocation. EX-1001, 9:24-49, 10:19-49.

305. You's resource patterns "indicate … a resource region in which the sPDSCH is transmitted within an OFDM symbol region." EX1004, 0222. By "indicate" You teaches that the specific resource region and related pattern and symbols therein are allocated, transmitted to the UE, and identified such as through DCI fields.

306. The "resource region" is an allocation of time-domain resources including one or more OFDM symbols as detailed below.

307. First, You's eNB transmits RRC signals that include "resource patterns" with resource configuration / allocation information.

> Each sPDSCH transmission resource pattern indicated by the RA field may be configured by an RRC layer. The UE may receive configuration information about the sPDSCH transmission resource pattern(s) through an RRC signal and determine that one of the sPDSCH transmission resource pattern(s) configured by the RRC signal is an sPDSCH transmission resource, based on the value of the RA field.

308. EX-1004, 0224. The "configuration information" discussed above teaches that the patterns are the configuration information and "configured by the RRC signal" in transmission to the UE. The UE receives the RRC signal, decodes/interprets it and is then "configured" because it has the

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necessary information to use the patterns to identify the specific regions of resources that are specified by the pattern index in the DCI.

309. You repeatedly states that RRC transmits resource allocation information. "Allocation of sPDSCH PRB … [t]he PRB resource in which the PDSCH can be scheduled may be … configured through RRC by the eNB." EX-1004, 0204-0205, 0215-0220. The PRB reflects the physical resource block which is a set of OFDM symbols in the time domain and frequency subcarriers in the frequency domain. EX-1004, 0065.

310. You's "resource patterns" include information on resource allocation such as the "resource region" allocated to PDSCH.

> Such an sPDSCH transmission resource pattern may indicate only a PRB resource region in which the sPDSCH is transmitted. Alternatively, the sPDSCH transmission resource pattern may indicate not only the PRB resource region in which the sPDSCH is transmitted but also a resource region in which the sPDSCH is transmitted within an OFDM symbol region in which the sPDCCH is transmitted in the PRB resource region in which the sPDSCH is transmitted.

311. EX-1004, 0222.

312. The resource region(s) within the patterns are defined in the time-domain by OFDM symbols and frequency domain by subcarriers. This is

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detailed in the description of You above in the Scope and Content of the Prior Art section.

313. You repeatedly teaches using the set of patterns to identify the allocated OFDM resources and selecting from that set through indication information sent to the UE in, for example, the DCI. "[A] plurality of resource patterns in which the sPDSCH can be transmitted may be defined and pattern information indicating through which pattern among the plural patterns the sPDSCH is transmitted may be used as the indication information." EX-1004, 0321.

314. You's "resource regions" are, or include, "information on one or more allocations of a time-domain resource, wherein the time-domain resource includes at least one or more orthogonal frequency-division multiplexing (OFDM) symbols" as claimed. You discloses "allocations of a time-domain resource" in multiple fashions that each allocate OFDM symbols.

315. For example, You teaches a "shortened TTI (sTTI)" (transmission time interval") with one or more OFDM symbols.

[0143] FIG. 6 illustrates the length of a transmission time interval (TTI) which is needed to implement low latency.

[0144] Referring to FIG. 6, a propagation delay (PD), a buffering time, a decoding time, an A/N preparation time, an uplink PD, and an OTA

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(over the air) delay according to a retransmission margin are produced while a signal transmitted from the eNB reaches the UE, the UE transmits an A/N for the signal, and the A/N reaches the eNB. To satisfy low latency, a shortened TTI (sTTI) shorter than or equal to 0.5 ms needs to be designed by shortening the TTI, which is the smallest unit of data transmission. For example, to shorten the OTA delay, which is a time taken from the moment the eNB starts to transmit data (PDCCH and PDSCH) until the UE completes transmission of an A/N for the data to the eNB, to a time shorter than 1 ms, the TTI is preferably set to 0.21 ms. That is, to shorten the user plane (U-plane) delay to 1 ms, the sTTI may be set in the unit of about three OFDM symbols.

[0145] While FIG. 6 illustrates that the sTTI is configured with three OFDM symbols to satisfy 1 ms as the OTA delay or U-plane delay, an sTTI shorter than 1 ms may also be configured. For example, for the normal CP, an sTTI consisting of 2 OFDM symbols, an sTTI consisting of 4 OFDM symbols and/or an sTTI consisting of 7 OFDM symbols may be configured.

[0146] In the time domain, all OFDM symbols constituting a default TTI or the OFDM symbols except the OFDM symbols occupying the PDCCH region of the TTI may be divided into two or more sTTIs on some or all frequency resources in the frequency band of the default TTI, namely the channel band or system band of the TTI.

316. EX-1004, 0143-146, 0058.

317. Thus, You expressly teaches the more granular allocation on the basis of individual or small groups of OFDM symbols in the time domain.

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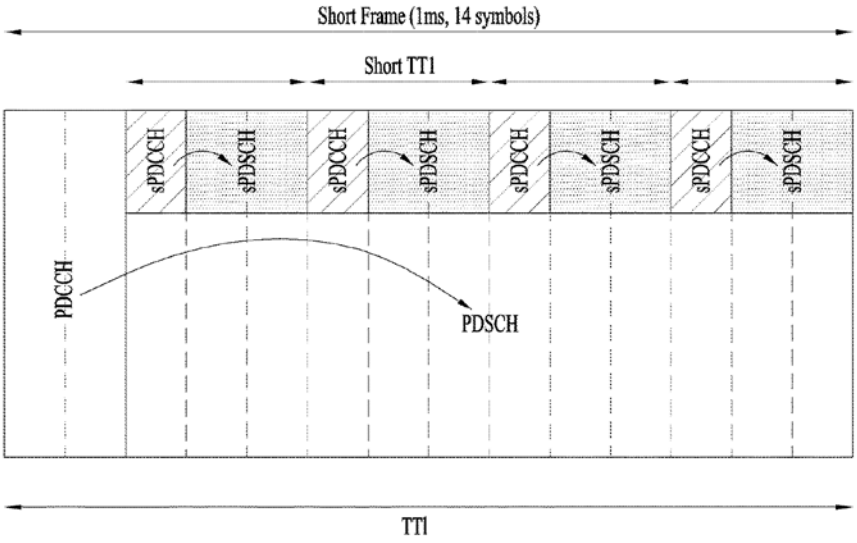
318. Notably, the '272 patent acknowledges that TTI is a "time domain scheduling unit" known in 3GPP EX-1001, 6:45-54. The "scheduling" reflects allocated OFDM symbols in the time domain for a TTI.

319. For example, Figure 7 shows a "TTI" with 14 symbols and four sTTIs each with three OFDM symbols.

FIG. 7



320.

321. EX-1004, Fig. 7. You teaches that these sTTIs are configured to allocate OFDM symbols.

[0148] FIG. 7 illustrates an sTTI and transmission of a control channel and data channel within the sTTI.

[0149] In the downlink environment, a PDCCH for transmission/scheduling of data within an sTTI (i.e., sPDCCH) and a PDSCH transmitted within an sTTI (i.e., sPDSCH) may be transmitted.

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> For example, referring to FIG. 7, a plurality of the sTTIs may be configured within one subframe, using different OFDM symbols. For example, the OFDM symbols in the subframe may be divided into one or more sTTIs in the time domain. OFDM symbols constituting an sTTI may be configured, excluding the leading OFDM symbols on which the legacy control channel is transmitted. Transmission of the sPDCCH and sPDSCH may be performed in a TDM manner within the sTTI, using different OFDM symbol regions. In an sTTI, the sPDCCH and sPDSCH may be transmitted in an FDM manner, using different regions of PRB(s)/frequency resources.

322. EX-1004, 0148-0149. These TTI reflect the type of resource allocation regions that You teaches in which there are fewer OFDM symbols than are present in a slot.

323. You's exemplary sTTIs have 2, 3, 4, or 7 OFDM symbols as quoted above. EX-1004, 0145. You's Figures 7-13 all show examples of sTTIs of 2-7 OFDM symbols. EX-1004, Fig. 7-13.

324. You teaches the allocation of OFDM symbols smaller than or equal to the number of OFDM symbols in a slot. "The eNB processor and the UE processor … are configured to allocate/decode a signal within an sTTI which is shorter than a legacy TTI. The sTTI may consist of OFDM symbols." EX-1004, 0332.

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[0146] In the time domain, all OFDM symbols constituting a default TTI or the OFDM symbols except the OFDM symbols occupying the PDCCH region of the TTI may be divided into two or more sTTIs on some or all frequency resources in the frequency band of the default TTI, namely the channel band or system band of the TTI.

325. EX-1007, 0146. This teaches that You is allocating the channels both in the time domain and the frequency domain on a basis that is smaller than (fewer symbols) the previous time domain allocations.

326. You teaches the basic organization of dividing a slot into symbols and allocating the resource elements as combination of individual OFDM symbols (in time domain) and subcarriers (in frequency domain) *See* EX-1004, 0062-0067 (describing transmission structure using "OFDM symbols in the time domain" and organized into resource blocks, slots, and resource elements comprised of OFDM symbols); Fig. 3.

327. You, like Gao, uses the term "time unit" to describe collections of OFDM symbols used for data transmissions. EX-1007, 0093.

328. You allocates "OFDM symbol regions" which transmit PDSCH data and which are allocated for sTTIs:

[A] PDSCH transmitted within an sTTI (i.e., sPDSCH) may be transmitted. For example, referring to FIG. 7, a plurality of the sTTIs may be configured within one subframe, using different OFDM

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> symbols. For example, the OFDM symbols in the subframe may be divided into one or more sTTIs in the time domain. OFDM symbols constituting an sTTI may be configured, …. Transmission of the …sPDSCH may be performed in a TDM manner within the sTTI, using different OFDM symbol regions.

329. EX-1004, 0149. The "configured" statement represents allocation because the resources are allocated and then transmitted to the UE to configure the UE and the transmission so that both sides of the transmission (BS and UE) understand the parameters defining the transmission in, for example, both the time domain and frequency domain.

330. You repeatedly explains that sTTI are configured in the time domain as collections of allocated OFDM symbols. *See* EX-1004, 0227 ("The sPRB may be configured by OFDM symbol(s) within the sTTI in the time domain…"); 0228 ("an sPRB for the sPDSCH … may be configured by OFDM symbol(s) within the sTTI in the time domain…"); 0199 ("allocating a PRB region in which the sPDSCH is transmitted within an sTTI…").

331. You's "resource patterns" may configure / allocate "resource regions" within "OFDM symbol regions" for PDSCH – used, for example, to establish sTTIs. EX-1004, 0222.

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332. Thus, based on the analysis above, the You's resource regions and "OFDM symbol regions" are an "**allocation of a time-domain resource**" of one or more OFDM symbols because the regions (and their associated sTTI) allocate OFDM symbols for regions in the time domain, and transmit that allocation to the UE to configure the transmission and UE as discussed above.

333. I also note that You's "sTTI" language appears (slightly differently) in the '272 patent in the preferred embodiment related to the claims.

334. In particular, in "Embodiment 1 Allocating on a Symbol Basis," the '272 patent relies upon a "short TTI" within slots that largely matches You:

> For example, for an NR UE on which a TTI is set as a unit of a slot formed of 14 symbols based on 15 kHz, in case 6 mini-slots formed of (2 symbols, 2 symbols, 3 symbols, 2 symbols, 2 symbols, 3 symbols) is defined in one symbol to support a short TTI for latency sensitive data, such as URLLC, in a corresponding cell, in configuring DL control information for transmitting UL/DL data scheduling control information for the NR UE, for the control information may include a symbol allocation information area including a bitmap of 6 bits.
>
> In this case, each bit forming bitmap configuration information of 6 bits is mapped to 1:1 on a group of symbols forming 3 mini-slots (e.g., the mini-slot formed of the 2 symbols or 3 symbols) defined in the slot, and according to the configuration information, a base station and the UE

> may additionally configure/obtain symbol allocation information to be used for data transmission/reception in a slot allocated for each UL/DL data transmission/reception.
>
> In this case, the size of the group of symbols used as a unit of symbol allocation (e.g., the number of symbols forming one symbol group) and the number of symbol groups (a corresponding bitmap size) may be determined by i) the size of a TTI set for the UE and ii) the size of a short TTI formed in the TTI (the size of a mini-slot corresponding to the short TTI, e.g., 2 symbols or 3 symbols in the above example) and the number of the short TTIs (6 TTIs in the above example). In this regard, a predefined value may be defined according to a SCS value supported by the cell and a SCS value and a TTI size used in a corresponding UE, or the configuration may be performed by a base station through cell-specific/UE-specific high layer signaling.

335. EX-1001, 9:21-10:18.

336. The embodiment from 10:19-11:55 also relies upon the "TTI set" which, as noted in the quotes above, is the set of short TTIs.

337. Thus, You's "sTTI" allocation embodiment appears to closely match the later '272 patent's embodiment.

338. This paragraph left intentionally blank].

[1.2] wherein, based on the information, a number of OFDM symbols are determined for a physical downlink shared

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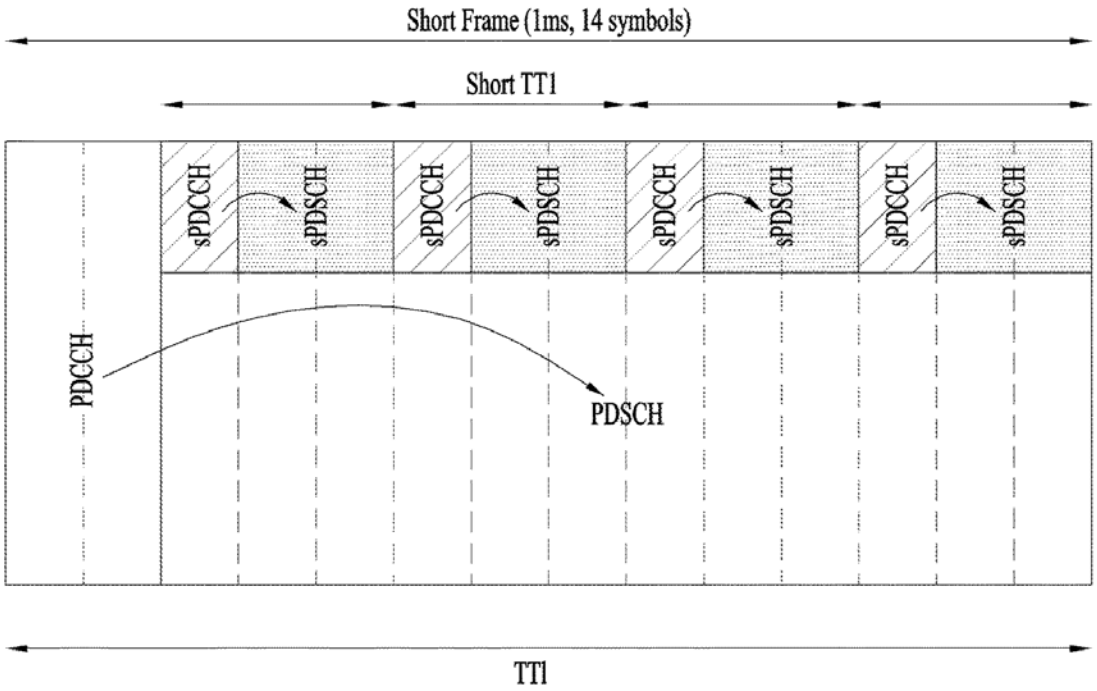
channel (PDSCH) or a physical uplink shared channel

(PUSCH), and;

339. You discloses this limitation for the reasons in [1.1] in which the sTTI and regions are configured (allocated and the allocation information transmitted to the UE). For example, You allocates OFDM symbols for PDSCH in Figure 7:

FIG. 7

340.



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341. EX-1004, Fig. 7. EX-1004, 0198-0225. "Determined" in this context includes to identify the number of allocated OFDM symbols (e.g., for the sTTI or regions). EX-1001, 10:5-12.

342. You's "sPDSCH" is "a shortened PDSCH" which is a PDSCH. EX-1004, 0038, 0149. For example, in the '272 patent embodiments that are used above, the PDSCH would be within the sTTI (just like You) and would also comprise what You references as a sPDSCH.

343. You's UE will "determine" the number of symbols by receiving the allocation configuration information and using that information to successfully receive, identify, and decode the allocated OFDM symbols for that particular UE.

344. As noted in [1.1], You's eNB determines the pattern of OFDM symbols allocated for each channel (e.g., PDSCH) as shown in Figs. 7-13. These patterns identify one or more "regions" and You's BS "determines" a number of OFDM symbols by specifying the specific "region" corresponding to PDSCH as detailed in [1.4] below.

345. You's BS communicates these patterns (and the regions specified therein) to You's UE through, for example, the "resource patterns" discussed in [1.1] which may be transmitted using RRC signals. EX-1004,

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0221-0224, 0321-0323. You's BS then identifies the specific "pattern" to You's UE using the DCI transmission as detailed below in [1.4]. The UE uses this DCI information to determine the specific OFDM symbols for a channel such as PDSCH and uses that information to receive the specific channels. EX-1004, 0332.

346. [This paragraph left intentionally blank].

[1.3] wherein the determined number of OFDM symbols is smaller than or equal to a number of OFDM symbols included in a slot; and;

347. You discloses this element.

348. The '272 patent teaches that a slot has 14 symbols. "[A] slot [may be] formed of 14 symbols." EX-1001, 7:7.

349. As detailed in [1.1], You teaches "sTTI" examples that contain PDSCH region allocations of 2, 3, 4, or 7 OFDM symbols. EX-1004, 0145. Thus, You teaches that "***the determined number of OFDM symbols is smaller than … the number … in a slot***."

350. Moreover, You's sTTI may contain 1 to 4 OFDM symbol used for PDCCH (not PDSCH). EX-1004, 0067, Figs. 7-13, 0222-0224. Thus, using You's examples of sTTIs with 2-4 or 7 OFDM symbols, the number

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of PDSCH OFDM symbols specified by the pattern(s) for the sTTI will be less than the number of OFDM symbols in a slot, including that the PDSCH may have only one symbol because some of the 2-4 or 7 symbols are used for PDCCH, not PDSCH (leaving the remainder for PDSCH). *See also* EX-1004, 0199-0220 (showing different "methods" in which PDSCH is within allocation including PDCCH and therefore less than the number of symbols in a slot). In a slot containing both PDCCH and PDSCH symbols, the number of PDSCH symbols is "***smaller than or equal to a number of OFDM symbols included in a slot***" as claimed for the same reason – that some of the OFDM symbols slot are used for PDSCH leaving the PDSCH with less than the number of symbols in the slot.

351. [This paragraph left intentionally blank].

[1.4] transmitting, to the wireless device, downlink control information (DCI), including a field including a bit string,

352. As noted in Ground 1, [1.4]-[1.6] recite a well-known data format for transmitting resource allocations in 3GPP systems. These elements recite: (1) using an "allocation table"; (2) the "allocation table" includes the start OFDM symbol and number of OFDM symbols; and (3) indexing the "allocation table" by DCI bits. You teaches (including rendering obvious)

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all of these concepts / elements – particularly in light of the well-known 3GPP usage of such tables which I have discussed in the Scope and Content Of The Prior Art above.

353. You transmits "***downlink control information (DCI)***" including a "resource allocation (RA) field." The RA field is a set of bits and corresponds to a bit string as I have discussed for the element above for the Gao reference. The DCI RA field identifies a specific resource patterns from the set of patterns:

[0221] Method 7. Resource Pattern Indication

[0222] To reduce the size of a resource allocation (RA) field of DCI, each value indicated by the RA field may mean a specific sPDSCH transmission resource pattern. For example, a pattern actually applied to an sPDSCH among 2^N sPDSCH transmission resource patterns may be indicated to the UE through N bits. ….

[0223] For example, an sPDSCH transmission resource pattern meant by each value indicated by the RA field may be configured as follows. With respect to each PRB size (i.e., the number of PRBs), multiple (e.g., 2) PRB patterns may be present. A PRB size of the sPDSCH and one pattern index among a plurality of PRB patterns for the PRB size may be indicated through the RA field. ….

[0224] Each sPDSCH transmission resource pattern indicated by the RA field may be configured by an RRC layer. The UE may receive configuration information about the sPDSCH transmission resource

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pattern(s) through an RRC signal and determine that one of the sPDSCH transmission resource pattern(s) configured by the RRC signal is an sPDSCH transmission resource, based on the value of the RA field.

354. EX-1004, 0221-0224. The DCI in existing 3GPP standards included a resource allocation "RA" field of bits. This is shown in the fields in the DCI in EX-1011 in section 5.3.3.1. For example, DCI format 1 has a "resource block assignment" field of bits which performs resource allocation:

- Resource block assignment:
  - For resource allocation type 0 as defined in section 7.1.6.1 of [3]:
    - $\lceil N_{RB}^{DL} / P \rceil$ bits provide the resource allocation
  - For resource allocation type 1 as defined in section 7.1.6.2 of [3]:
    - $\lceil \log_2(P) \rceil$ bits of this field are used as a header specific to this resource allocation type to indicate the selected resource blocks subset
    - 1 bit indicates a shift of the resource allocation span
    - $\left(\lceil N_{RB}^{DL} / P \rceil - \lceil \log_2(P) \rceil - 1 \right)$ bits provide the resource allocation

where the value of P depends on the number of DL resource blocks as indicated in section 7.1.6.1 of [3]

355. EX-1011, Section 5.3.3.1.2.

356. You teaches three options for a DCI field to transmit the pattern index of resource patterns.

[A] plurality of resource patterns in which the sPDSCH can be transmitted may be defined and pattern information indicating through which pattern among the plural patterns the sPDSCH is transmitted may

be used as the indication information. The indication information indicating a resource pattern used for transmission of the sPDSCH may be transmitted through an explicit field in DCI, may be transmitted using an additional one or multiple bits in an RA field, or may be transmitted through the RA field.

357. EX-1004, 0321.

358. You teaches that the DCI includes information that provides resource allocation for the UE in numerous places. *See* EX-1004, 0322-323, 0320, 0074 ("DCI includes resource allocation information for a UE"); 0152 ("DCI may configure a transmission resource of the sPDSCH/sPUSCH…."). Identifying the specific pattern for a particular resource allocation (including for a sTTI) is one example of the DCI provide the bits to indicate the resource allocation.

359. A POSITA would understand You's use of a DCI field to include "a field including a bit string." As discussed above, You discloses "2^N sPDSCH transmission resource patterns may be indicated to the UE through N bits." EX-1004, 0222. Thus, for example, if You's "N" was three, there would be 3 DCI bits that are used to index one out of 2^N (= 8) patterns. Notably, as discussed above, the '272 patent does not use the term "string" and merely relies upon the knowledge of a POSITA that a DCI is comprised of sets of related bits.

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360. If PO argues that a "bit string" is different from You's disclosure of using bits as an index, then You's disclosure would, at a minimum, render obvious such a bit string. To make such an argument, PO would have to assert that four bits such as "1011" is different in a "string" format from the binary interpretation of 1011 (which would be a decimal value of 11). No disclosure in the '272 patent supports such a distinction nor is it patentable. This is particularly true because the '272 patent does not use "string" or "bit string" in its specification. Thus, at a minimum, You teaches at least as much as the '272 patent.

361. You teaches a highly optimized mechanism in which the number of bits in the RA field used for identifying the pattern is minimized. EX-1004, 0222. A POSITA recognizes that such optimization provides benefits by reducing the overall number of bits necessary to transmit wirelessly to identify the allocation information (resource patterns).

362. As You notes, there are benefits to minimizing the bits in the DCI. The reason is because the DCI is frequently transmitted (every frame to provide allocation information for the related PDSCH and other channels). Thus, minimizing the bits in the DCI minimizes the bits needed for the control

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information in the PDCCH which allows more of the available bandwidth for the PDSCH which is transmitting the data.

363. If PO argues that the bit string must be included as part of the allocation table, a POSITA would recognize that You's disclosure, at a minimum, renders obvious such an implementation of the patterns. As detailed in Section IX.C, it was known within 3GPP to include such bit strings in resource allocation tables. Moreover, the disclosure in the '272 patent (and the Priority Application) is virtually identical to known structures in 3GPP standards.

364. Moreover, the usage as a "row index" would be more efficiently effectuated by an implementation in which the bits are used to index into the table directly. If the bit string must be matched against a bit string in the table, the UE must perform a series of comparisons against each row in the table to attempt to match the bit string. This is inefficient. For that reason, a typical implementation would be understood to calculate the row index based upon the DCI and use that calculation to directly access the information in the table row.

365. A POSITA viewing You's disclosure would understand that You renders obvious multiple implementations. In one implementation, the DCI

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bit string itself is interpreted as the row index into the resource pattern table. In another implementation, the DCI bit string may be matched against bit strings in the resource pattern table to identify the row in the resource pattern allocation. Selecting from two well-known implementations is, at a minimum, obvious over You's disclosure.

366. Moreover, to the extent that the '272 patents are limited to a particular implementation, such implementation does not provide patentability – particularly in light of the known 3GPP implementations and the '272 patent's effective copying of such 3GPP implementations. The ability to calculate offsets into a table data structure is a well-known and fundamental aspect of computer science going back many decades. Similarly, comparing two values to determine if they match (such as bit strings in a row index) is also well-known in the computer science field for many decades.

367. [This paragraph left intentionally blank].

[1.5] wherein the bit string in the field relates to a row index of an allocation table, and.

368. You renders obvious this element. As detailed in [1.1]–[1.4], You describes "a plurality of resource patterns." A POSITA would understand

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that one obvious implementation of the set of resource patterns would be in a table. The resource patterns contain grouped sets of data that You discloses as being accessed efficiently. Arranging the sets of data into a table in which each row represents a particular pattern (grouped set) of data reflects an obvious implementation design choice. EX-1004, 0221-0224, 0321.

369. As detailed in [1.4], You teaches a DCI "RA" field which is a "pattern index" identifying a "specific sPDSCH transmission resource pattern." EX-1004, 0222. Such a pattern index makes it even more obvious that the patterns would be implemented in a format (such as a table) in which an index is used to identify a specific pattern in the overall groupings of patterns. A POSITA would recognize that You's "resource patterns" (detailed in [1.1]-[1.4]) render obvious an "allocation table" implementation of the patterns.

370. In such an obvious implementation, each "pattern" identifies an allocated region for the PDSCH as detailed in [1.1]-[1.3]. EX-1004, 0222-0224, 0321.

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371. While You does not explicitly recite that the patterns are a "table," the lack of usage of the word "table" does not impact that such table data structures are an obvious implementation of You's patterns.

372. Also, a POSITA would recognize that You's collection of resource patterns renders obvious an implementation in the claimed "table" format, including for the same reasons cited for Gao in Ground 1 for [1.6].

373. A POSITA would understand a "table" to be rendered obvious by a set of data entries in which each entry (row) may be identified (indicated) by an index as I have discussed above in the Scope and Content of the Prior Art section. You describes such a set of data entries in which each pattern reflects a grouped set of data. There is a set of "resource patterns" in which a "pattern index" (bits in the RA field) identifies / indicates each entry in the set. At a minimum, such disclosure renders obvious the usage of a table data structure to efficiently access individual patterns within the grouped set of patterns.

374. The '272 patent mirrors You's (earlier) disclosure of using a number of bits ("N") in the DCI to index 2^N rows corresponding to entries in the '272 patent's table. The '272 patent's examples use three bits for 8 table rows and 4 bits for 16 rows. EX-1001, 10:19-11:58. This corresponds to You's

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teaching that the number of bits ("N") can index 2^N patterns. EX-1004, 0222. Similarly, the '272 patent uses the term "indication information" to reference the DCI field identifying the table entry for PDSCH and PUSCH allocations. EX-1001, 11:49-55;10:22-24. You similarly uses the term "indicate" to refer to the process of identifying the resource pattern (table) entry that includes PDSCH allocations. EX-1004, 0222-0224.

375. Thus, a POSITA would understand that You's resource patterns render obvious the claimed "allocation table" implementation under any reasonable understanding of "table" and the DCI RA field would provide a row index into such a table to identify the specific pattern within the table of patterns to be used for a particular resource allocation.

376. [This paragraph left intentionally blank].

[1.6] wherein the allocation table includes information on a starting OFDM symbol and the number of the OFDM symbols which is smaller than or equal to the number of OFDM symbols included in the slot.

377. You renders obvious this element alone, or in combination with Gao. As detailed in [1.3-1.5], You allocates OFDM symbols within "regions" identified within a set of "resource patterns" that render obvious the claimed

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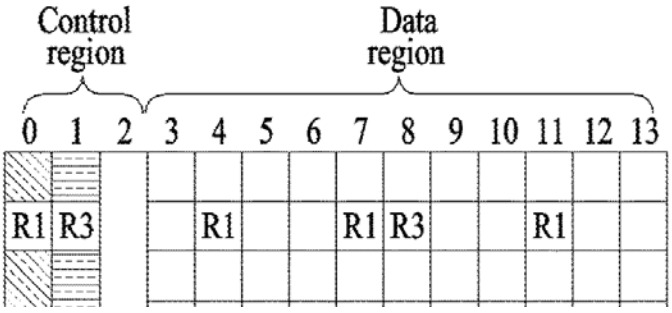
"***allocation table***." As detailed for [1.3], You's allocated number of OFDM symbols is "***smaller than … the number of OFDM symbols included in the slot***."

378. A POSITA would understand You's "regions" within the "patterns" to disclose, or suggest, "***information on a starting OFDM symbol and the number of the OFDM symbols***" for each pattern as detailed below. Thus, You's disclosure by itself renders obvious claim 1.

379. First, You's "regions" teach or suggest the start OFDM symbol and number of symbols in the "region." The plain meaning of "region" within You's context includes a specific identification of a starting point and number of OFDM symbols. You's Figure 3 exemplifies "regions."

FIG. 3

380.



381. . . .

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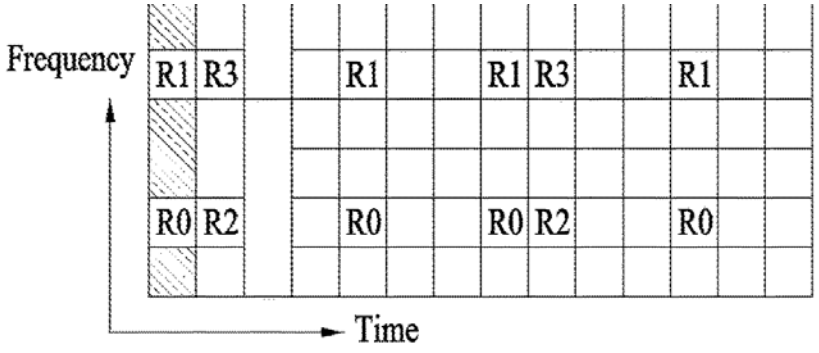
382. 

383. EX-1004, Fig. 3 (excerpted). You defines "regions" in terms of OFDM symbols including the starting OFDM symbol and the length/number of symbols in the time domain:

> Referring to FIG. 3, a maximum of 3 (or 4) OFDM symbols located in a front part of a first slot of a subframe corresponds to the control region. Hereinafter, a resource region for PDCCH transmission in a DL subframe is referred to as a PDCCH region. OFDM symbols other than the OFDM symbol(s) used in the control region correspond to the data region to which a physical downlink shared channel (PDSCH) is allocated. Hereinafter, a resource region available for PDSCH transmission in the DL subframe is referred to as a PDSCH region.

384. EX-1004, 0067. Thus, in the time-domain, the "region" is defined by the OFDM symbol start location and number of symbols *See also* EX-1004, 0222 ("sPDSCH transmission resource pattern may indicate not only the PRB resource region in which the sPDSCH is transmitted but also a resource region in which the sPDSCH is transmitted within an OFDM symbol region in which the sPDCCH is transmitted in the PRB resource

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region in which the sPDSCH is transmitted"); 0149 ("OFDM symbols constituting an sTTI may be configured, … Transmission of the sPDCCH and sPDSCH may be performed in a TDM manner within the sTTI, using different OFDM symbol regions").

385. You devotes an entire section to "D. Starting OFDM Symbol location of sPDSCH Transmission." EX-1004, 0226-0300. Within Section D, You describes methods of identifying the starting PDSCH OFDM symbol location. One method corresponds to the "patterns" identified above. First, You repeatedly states that "[t]he sPDSCH transmission starting OFDM symbol location may be semi-statically configured by the eNB through … an RRC signal." EX-1004, 0243, 0248, 0262, 0268, 0279, 0285, 0292. This "RRC signal" corresponds to You's teaching that the patterns are transmitted using RRC signals as detailed for [1.1]. A POSITA would understand this teaching to disclose that the "starting" OFDM symbol location would be identified within the patterns configured by RRC because those patterns seek to identify the specific resource region(s) used for allocation. Because the regions are specified by particular OFDM symbols in the time domain, it would be, at a minimum, obvious for the patterns to

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include the start position and number of symbols for the PDSCH which is being allocated for the region.

386. Second, a POSITA would have understood that one known obvious implementation of "resource patterns" was an allocation table including the start resource and the number of allocated resources because the purpose is to identify a specific region using the pattern and the region can be most efficiently identified through information regarding its bounds which would include the start OFDM symbols and the number of OFDM symbols in the time domain.

387. Third, if PO argues that You does not disclose this element, then You combined with Gao discloses that each pattern includes "information on a starting OFDM symbol and the number of the OFDM symbols." As detailed in Ground 1, Gao's teaches a system very similar to You in which the BS allocates OFDM symbols for transmitting PDSCH and PUSCH using "patterns."

388. Gao's allocation patterns include "information on a starting OFDM symbol and the number of the OFDM symbols." Supra, Ground 1, [1.6] (incorporated by reference herein). E.g., EX-1007, 0011-0012 ("each

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pattern includes an allocation of a length and a position of the [] region in the time unit").

389. Thus, in this proposed combination, You's resource patterns (supplemented by Gao's teachings) include (at a minimum) the position of the PDSCH region ("***a starting OFDM symbol***") and the length of the region ("***the number of the OFDM symbols***").

390. Such an implementation of You (using Gao's express identification of the pattern information) would allow You to efficient identify and specify the bounds of the resource regions being allocated and configured for the UE communicating with the BS.

391. As detailed in [1.3], the number of OFDM symbols for PDSCH is smaller than the number of OFDM symbols in the slot.

392. [This paragraph left intentionally blank].

b) <u>Claims 8 and 15</u>

393. As noted for Ground 1, claims 8 and 15 substantively match claim 1 written from the perspective of the UE ("wireless device") receiving signals transmitted by the BS recited in claim 1.

394. You's "receiving device" discloses the claimed "wireless device" that receives allocation information and determines allocated symbols based on

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the configured allocation information received from the UE EX-1004, Fig. 14, 0324-0334.

395. You's "receiving device" is "UE" – matching the '272 patent's terminology. EX-1001, 4:40-53; EX-1004, 0003-0008, claims 1-10. The UE performs the reception and determination of OFDM symbols using the configurations and allocation information identified by the BS as discussed above for claim 1.

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C. Analysis of Dependent Claims 2-7, 9-14, and 16-20 For Grounds 1 And 2.

397. The analysis of the dependent claims is the same for Ground 1 and Ground 2 and does not depend upon which of Gao or You is used as the primary reference. The dependent claims recite features and functionality largely separate from the independent claims.

398. Dependent claims 9-14 recite substantively the same elements as claims 2-7. Claims 16-20 recite substantively the same elements as claims 2-6. Thus, claims 9-14 and 15-20 are invalid for the same reasons discussed above for claims 2-7 and these claims are presented together.

399. [This paragraph left intentionally blank]

c) Claims 2, 9, 16

i. The base station [wireless device / method] of claim 1 [8 / 15], wherein the bit string is 3 bits in length.

400. This limitation is disclosed by the combinations in Grounds 1 and 2. The bit string size reflects an implementation detail related to the maximum number of allocation table entries and does not independently impart

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patentability. The '272 patent does not identify any benefit to "3 bits" over any size. Moreover, the '272 patent does not, in fact, use the terms "string" or "bit string" in the specification.

401. The closest the '272 patent comes to such a teaching of using 3 bits is Table 1. As I have noted elsewhere herein, Table 1 appears in the Priority Application and appears to directly derive from prior 3GPP standards which had almost identical exact tables.

402. Gao's disclosure does not limit the number of pre-defined patterns in Gao's patterns set. Thus, Gao, at a minimum, renders obvious any number of patterns including, for example, a set of eight patterns that could be uniquely, and efficiently, indexed by 3 DCI bits.

403. You identifies why, and how, a POSITA would select a specific number of bits:

> To reduce the size of a resource allocation (RA) field of DCI, each value indicated by the RA field may mean a specific sPDSCH transmission resource pattern. For example, a pattern actually applied to an sPDSCH among 2^N sPDSCH transmission resource patterns may be indicated to the UE through N bits. ….

404. EX-1004, 0222. Thus, for example, a bit string of 3 bits can efficiently index $2^3 = 8$ different patterns.

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405. Moreover, given You's teaching of the benefit of reducing the number of DCI bits, a smaller field that still provides sufficient flexibility for specifying particular different patterns to be able to allocate resources on different bases would be obvious. Arriving at a size of 3 bits would be obvious – particularly because such a size was already known to a POSITA as reflected in the discussion of 3GPP36-213 herein.

406. Thus, the combination discloses this claim.

d) <u>Claims 3, 10, 17</u>

ii. The base station [wireless device / method] of claim 1 [8 / 15], wherein the DCI further includes information on one or more allocations of a frequency-domain resource.

407. This limitation is disclosed by the combinations. The sole disclosure within the '272 patent related to this element is one passage stating "allocation information of frequency resource (RB) … may be included in DL control information." EX-1001, 9:8-12. The combined disclosure of You and Gao discloses this claim in greater detail and thus renders this claim obvious.

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408. You (like the '272 patent) identifies that "Resource blocks (RBs)" are allocations "in the frequency domain." EX-1004, 0062. In You, "[t]he DCI includes resource allocation information for a UE…." EX-1004, 0074. You's allocations include different frequency blocks. EX-1004, [0063-0067]. You's RB is "mapped to one physical resource block (PRB)" and "N^{RB}_{sc} (e.g. 12) consecutive subcarriers in the frequency domain." EX-1004, 0064-0065.

409. You's "PRB resource location within the PRB resource may be transmitted through DCI or fast DCI." EX-1004, 0202-0203. You repeatedly teaches that the DCI information can include the PRB resource location. EX-1004, 0206-0209. The "PRB resource location" identifies the specific PRB and discloses "***information on one or more allocations of a frequency-domain resource***."

410. Moreover, You teaches that the TTI or sTTIs may occupy "some or all frequency resources in the frequency band of the default TTI." EX-1004, 0146. Identifying "some" of the allocated frequency resources teaches using information in the DCI.

411. Furthermore, You teaches that "[a] PRB size of the sPDSCH and one pattern index among a plurality of PRB patterns for the PRB size may be

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indicated through the RA field." EX-1004, 0223. The RA field is within the DCI. EX-1004, 0222. Given that "PRB size" is "the number of PRBs" allocated and the number of PRBs relates to the frequency allocation, the PRB size in the DCI discloses "information on one or more allocations of a frequency-domain resource."

412. Figures 7-13 show the allocated regions including that such regions have bounds in the frequency range. For example, Figure 11 shows that the sPDSCH resource comprises only a portion of the available subcarriers in the frequency domain. It would be an obvious inclusion in the DCI to provide information regarding the particular subcarriers to be used for any particular allocation.

413. Thus, this combination discloses claim 3.

414. It would also be obvious to include such frequency allocation information because Gao and You each describe "regions" for allocations. Such "regions" are defined in one axis by time (OFDM symbols) and in the other axis by frequency. Thus, to be able to define a 2-dimension region, a POSITA would have found it obvious that not only would the time domain axis have been included in the DCI, but the frequency domain axis

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information would also be included to be able to define what frequency domain resource extents are allocated by the "region."

415. Finally, given that the existing 3GPP standards already included a DCI field with "***information on one or more allocations of a frequency-domain resource***," it would have been obvious to include such information when implementing Gao and/or You. *Infra*, Grounds 3 and 4.

e) <u>Claims 4, 10, 18</u>

iii. The base station [wireless device / method] of claim 1 [8 / 15], wherein the base station supports a new radio access technology (NR).

416. This limitation is disclosed by Gao and You.

417. "New Radio" ("NR") is referenced as "next-generation/5G radio access network" as a known technology. EX-1001, 1:21-23, 3:52-59. The inventions of You, Gao (and the '272 patent) are all in the context of the 3GPP working groups developing the standards for the NR access technology – as shown in the RAN1#86-Bis materials that the inventor referenced and accessed to copy portions thereof in the Priority Application.

418. Gao discloses BSs "in the existing 5G system." EX-1007, 0008, 0095. You's BSs use "new radio access technology (RAT)" for "next generation

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communication" in "next-generation RAT" for a "new RAT environment." EX-1004, 0135, 0147.

f) <u>Claims 6, 13, 20</u>

iv. The base station [wireless device / method] of claim 1 [8 / 15], wherein the operations further include: transmitting, to the wireless device, downlink data via the PDSCH; and receiving, from the wireless device, uplink data via the PUSCH.

419. You and Gao each discloses this element for the same reasons discussed in [1.1]-[1.3] in Grounds 1 and 2. *E.g.*, EX-1004, 0333; 0077 (PDSCH); 0198-0300 (sPDSCH); 0087 (PUSCH). Gao discloses data transmissions on PDSCH and PUSCH. Gao's "UE receives a corresponding downlink shared channel ("***PDSCH"***)" transmitted by the eNB via PDSCH. EX-1007, 0160. See also EX-1007, 0161-0162; 0153-0155; 0173-0175; 0180-0182. Similarly, Gao's "UE [] transmits a corresponding uplink shared channel ("***PUSCH***") …" received by the eNB via PUSCH. EX-1007, 0163-0164; 0180, 0183-0184, 0124, 0156-0157; Figs. 2-3, 20-22.

g) <u>Claim 7</u>

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v. 7. The base station of claim 1, wherein the number of the OFDM symbols is a maximum of 14.

420. Gao' regions with PDSCH and PUSCH symbols include 1, 2 or 3 symbols. EX-1007, 0140. *Supra*, Ground 1, [1.1]-[1.3]; You teaches "sTTI" examples containing PDSCH region with 1-4 or 7 OFDM symbols. EX-1004, 0145. *Supra*, Ground 2, [1.1]-[1.3].

421. [This paragraph left intentionally blank].

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D. Grounds 3 and 4: Claims 1-20 Are Invalid Over Grounds 1 and 2 in further view of 3GPP36-213 and 3GPP36-212

423. As detailed in Section IX.C (which is incorporated herein), 3GPP36-213 implements resource allocation using a "table" format and 3GPP36-212 shows a DCI with bits to index an entry in that table format.

424. If PO asserts that Gao's and You's "patterns" do not render obvious an implementation that uses a "table" data structure, 3GPP36-213 and 3GPP36-212 supply a POSITA's knowledge for such an implementation.

425. In the Grounds 3 and 4 combinations, the "patterns" in Gao and/or You would be implemented using the data structure of a resource allocation table.

426. A POSITA would recognize that a "table" as articulated in the 3GPP standards would be one of a few known design choices for implementing the sets of patterns discussed in Gao and You. Each pattern reflects an organized set of related data, and a POSITA would recognize that the well-known table format provides an efficient and obvious vehicle in which to associate the individual patterns for efficient access.

427. Moreover, a POSITA would recognize You's stated advantage that 2^N bits can efficiently index N patterns and that a table provided an implementation to achieve these efficiencies. *See* Ground 2, [1.4]-[1.6].

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428. Thus, in this proposed combination, the primary reference (Gao and/or You) provides the information / data used within the table (*e.g.*, the "resources" defined at the OFDM symbol-level in Grounds 1 and 2 at [1.1-1.3], [1.6]). 3GPP36-213 provides the data structure format (table) in which to incorporate the data. EX-1010, Section 8.1.3.

429. 3GPP36-212 confirms the teachings in You and Gao that DCI bits can be used to index the patterns (implemented as a table) to select one of the patterns (table row). EX-1011, Section 8.1.3.

430. While the 3GPP36-213 table allocates "resources" that are not at the OFDM symbol granularity, it is not being relied upon for the type of allocated resources, but rather the format specifying the allocated resources. As noted in Gao, You, and the 3GPP working group papers, it was well known that more granular "resource" allocation at the OFDM symbol level was desired and intended for usage in the NR standards. Thus, applying the previous generic "resource" allocation structure to a more refined and granular form of resources well known to a POSITA is merely just an obvious implementation using known data structures for their intended purposes.

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431. A POSITA would find it obvious to combine 3GPP36-213 and 3GPP36.212 with a reasonable expectation of success because they reflect corresponding portions of the same wireless standard that explicitly cross-references sections defining the table and index usage described herein. Moreover, the usage of the table structure would be well within the skill of a POSITA given that such table structures are well-known and pervasively used in the computer science field for many decades prior to the '272 Priority Application.

432. I also note that the '272 patent does not provide any particular information that would guide a POSITA as to how such a structure would be implemented. Rather, the '272 patent just recites to use a table data structure, and the accompanying indexing, and relies upon the knowledge of a POSITA for implementing such a structure. Such knowledge would also be known and available to a POSITA in viewing the prior art in the Grounds specified herein and would provide a reasonable expectation of success in implementing such known technology.

433. **Claims 2/9/16**. If PO asserts patentability based on the specific number of bits ("3 bits") in the DCI, 3GPP36-213 and 3GPP36-212 explicitly shows a resource allocation table that is indexed by 3 DCI bits.

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434. **Claims 3/10/17**. Existing 3GPP standards already included frequency resource allocation information. *E.g.*, EX-1011, Section 5.3.3.1 ("DCI formats") at §§5.3.3.1.2-5.3.3.1.5D, 5.3.3.1.8-5.3.3.1.14 (nineteen DCI format with "resource block assignment"). "Resource block assignment" represents "information on one or more allocations of a frequency-domain resource" because, for example, it is information on "resource block groups" that are "indexed in the order of increasing frequency… starting that the lowest frequency." EX-1010, Section 7.1.6.1; EX-1001, 2:21-23 ("resource blocks" are allocation "in the frequency domain").

435. Thus, these claims would be obvious in light of the known and pervasive use of DCI information to specify frequency allocation for the transmissions to / from the UE.

436. [This paragraph left intentionally blank].

E. Ground 5: Claims 5, 12, and 19 Are Invalid Over Grounds 1-4 in further view of R1-1610129.

h) Claims 5, 12, 19

vi. The base station [wireless device / method] of claim 1 [8 / 15], wherein the base station supports different numerologies which are defined by a subcarrier spacing (SCS).

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437. The proposed combinations disclose this limitation. These claims attempt to specify that different numerologies correspond to different SCS. However, the '272 patent did not describe any such relationship between a numerology and SCS beyond that which was already known to a POSITA.

438. The '272 patent acknowledged that, in the 3GPP working groups, "methods have been discussed for … supporting numerologies each having different SCS values…." EX-1001, 7:29-34, 6:48-51. Thus, this Ground merely adds the 3GPP "discussions" as reflected in R1-1610129 in which BS's support numerologies defined by SCS.

439. Subcarrier spacing reflects the distance between adjacent subcarriers – effectively the reciprocal of the symbol time. It is frequently expressed in terms of kHz. E.g., EX-1001, 6:60-65, 7:19-41.

440. R1-1610129 extensively describes numerous proposals in which the BS supports different numerologies defined by SCS. EX-1020, 0004-0013. For example, NTT Docomo presented the following example of numerologies for different SCS:

SCS	15kHz	30kHz	60kHz	120kHz	240kHz	480kHz
No. of symbols per Tx duration	14/7	14/7	14/7	28/14	56/28	112/56
Tx duration in ms (depends on ref. num., this may not be exact)	1ms/ 0.5ms	0.5ms/ 0.25ms	0.25ms/ 0.125ms	0.25ms/ 0.125ms	0.25ms/ 0.125ms	0.25ms/ 0.125ms

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441. EX-1020, 0004-0005. The different SCSs are shown on the top line (15-480 kHz). This is what the (later) '272 patent describes.

442. Many other companies presented similar numerologies defined by SCS. EX-1020, 0002 (identifying SCS's from 15kHz to 480kHz for the different numerologies), 0005-0006 (Panasonic), 0007 (Fujitsu), 0008 (MediaTek, Nokia, Samsung), 0009-0010 (CATT, LG, ETRI, Intel). Notably absent is any contribution from KT Corporation (that employed the '272 patent inventors).

443. The entirety of the discussion of "numerologies" and "subcarrier" spacing in the '272 patent relates to these known and existing 3GPP NR "discussions." EX-1001, 6:49-7:44. The '272 patent inventors did not add any novel concepts that were unknown to the 3GPP participants in these discussions prior to the Priority Application.

444. A POSITA would have recognized the benefits of supporting numerologies defined by SCS. For example, the '272 patent acknowledges that the 3GPP working groups recognized that the new functions of "eMBB, mMTC, and URLLC" would benefit from numerologies defined by SCS. EX-1001, 6:45-53. This was already known to a POSITA that these different services could benefit from being allowed to operate on different

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SCS. Defining numerologies based on such different SCS allowed for an efficient manner of specifying and implementing such services.

445. For example, "methods of satisfying each requirement of URLLC and eMBB have been discussed by defining different SCSs" by the 3GPP NR working groups. EX-1001, 7:41-45.

446. The "discussions" cited by the '272 patent are reflected in the R1-1610129 submission (summarizing ideas from other companies) which contains extensive discussions about BS supporting different numerologies defined by subcarrier spacings to support eMBB and URLLC. EX-1020 at Section 1.1 ("Slot Lengths and Subcarrier Spacings"); 0004-0011 (every submission discussing numerologies and subcarrier spacings for eMBB and URLLC). These discussions reflect that it was known to (and obvious to) a POSITA that the upcoming NR standard would benefit from numerologies defined by different SCS as claimed and as taught in this reference.

447. Gao's BS supports separate patterns with eMBB and URLLC.

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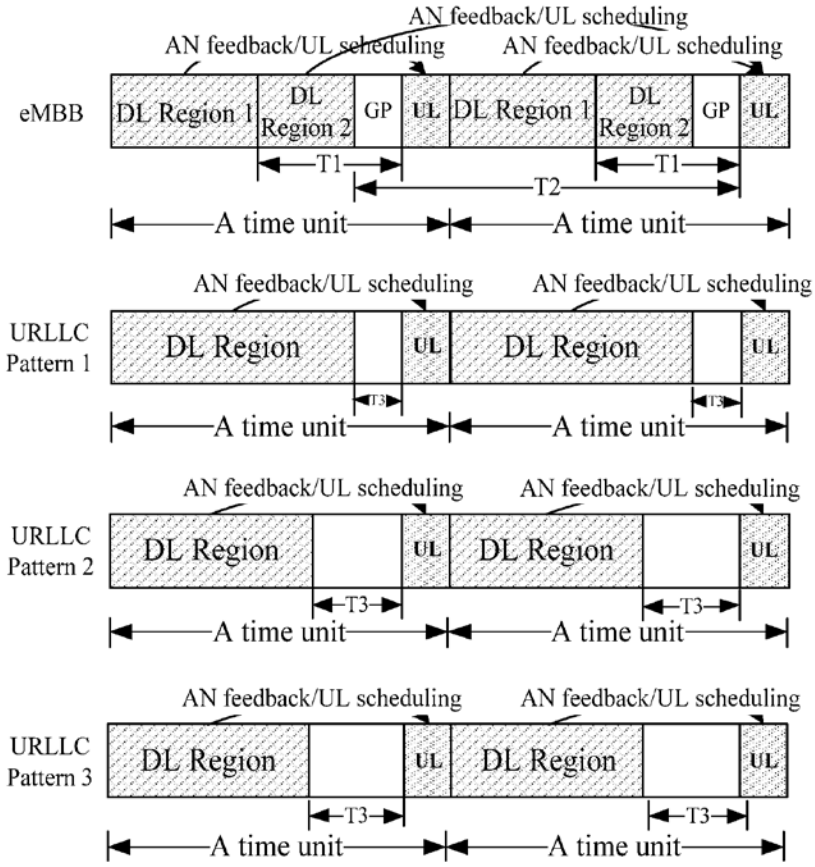

Fig. 10

448.

449. EX-1007, Fig. 10. Gao teaches that both eMBB and URLLC can be supported together. EX-1007, 0168, 0188 Figs. 11, 18-19.

450. Thus, because it was known that eMBB and URLLC would benefit from different numerologies based upon subcarrier spacings and because Gao supports both eMBB and URLLC, a POSITA would understand that it would be obvious that Gao's BS would support multiple numerologies based on SCS to allow for efficient implementation of the service.

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451. You teaches mMTC and URLLC and a POSITA would understand You to benefit similarly from the different numerologies based on SCS in light of R1-1610129. EX-1004, 0133-0135.

452. The motivation for such a combination would be the benefits (as recognized by the 3GPP working group and repeated in the '272 patent) of different SCS supporting the different requirements and being able to efficiently leverage such different SCS through supporting different numerologies based thereon. There would have been a reasonable expectation of success because the various companies were proposing supporting multiple SCS as detailed above for implementation in the standard with overlapping implementations that the companies recognized could be adapted to work together to allow for different numerologies based on the subcarrier spacings. Moreover, as noted above, the '272 patent does not teach any particular implementation aspect of different SCS and relies upon the knowledge of a POSITA for such implementation. Such knowledge is available to a POSITA when considering the prior art as well.

453. Thus, these claims are obvious because: (1) the '272 patent merely copied this element from pre-existing "discussions" in the 3GPP NR working groups; and (2) R1- 1610129 reflects these discussions disclosing

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the elements and a POSITA would recognize these to be obvious from the disclosures of Gao and You.

454. [This paragraph is left intentionally blank].

XI. SECONDARY CONSIDERATIONS DO NOT REBUT THE PRIMA FACIE CASE OF OBVIOUSNESS

455. In my opinion, secondary considerations do not rebut the prima facie case of obviousness as stated above. *First*, I have not seen any evidence of any secondary consideration to date.

456. The applicant did not proffer any evidence during prosecution of the '272 patent which, as a discussed above, was abbreviated and without significant interaction between the Examiner and the applicant.

457. *Second*, it seems unlikely that there is any nexus between any alleged secondary considerations of nonobviousness and the specific claim elements. I have been advised that a nexus does not exist where the alleged secondary consideration results from something other than what is both claimed and novel in the claims.

458. As detailed herein, the prior art teaches each of the claim elements. Moreover, as discussed above, the claim elements appear to reflect

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information that was discussed in 3GPP working groups prior to the filing of the Priority Application. Moreover, the table structure that is recited in the Priority Application appears to closely match an existing table structure that was already present in 3GPP standards as detailed herein. Thus, the Patent Owner likely will not be able to establish the nexus between any novel aspect of the claims (there is no such aspect) and any evidence reflecting secondary considerations of nonobviousness.

XII. CONCLUSION

459. I may utilize the documents cited and/or listed herein, or portions of those documents, as exhibits at any hearing or trial in this proceeding. I may further prepare and use exhibits that summarize portions of my testimony or key terms or concepts presented therein, or other demonstrative exhibits, at any hearing or trial in this proceeding.

460. I reserve the right to supplement my testimony and this report in response to any judicial determinations, in response to the opinions expressed by the Patent Owner's experts in this proceeding, and/or in light of additional evidence or testimony brought forth at trial or otherwise brought to my attention after the date of my signature below.

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461. I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1004.

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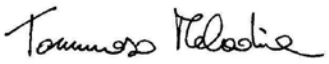
Date: December 17, 2024



Tommaso Melodia

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EXHIBIT A

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RESEARCH INTERESTS

- Modeling, optimization, and experimental evaluation of wireless and network systems.
- Applications to Internet of Things, 5G and beyond networks; artificial intelligence in wireless; spectrum sharing; Open RAN.

EDUCATIONAL BACKGROUND

GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta, GA USA

Ph.D. in Electrical and Computer Engineering **2004-2007**
Thesis: "*Communication and Coordination in Wireless Multimedia Sensor and Actor Networks*"

UNIVERSITY OF ROME LA SAPIENZA, Rome, Italy

Doctorate in Information and Communication Engineering **2002-2005**
Thesis: "*Routing and topology optimization in the energy and latency domains for ad hoc and sensor networks*"

Laurea (equivalent to integrated M.S. and B.S.) in Telecommunications Engineering **2001**
Laurea Thesis: "*Bluetooth Ad Hoc Networks: Topology And Radio Resource Management*"

EMPLOYMENT HISTORY

William Lincoln Smith Professor - Northeastern University	**July 2018**
Director - Institute for the Wireless Internet of Things	**July 2018**
Director of Research - PAWR Project Office	**March 2017**
Associate Professor - Northeastern University	**August 2014**
Associate Professor - SUNY Buffalo	**October 2012**
Assistant Professor - SUNY Buffalo	**August 2007**
Research Assistant - Georgia Institute of Technology	**2004-2007**
Research Assistant - University of Rome La Sapienza	**2002-2003**

OTHER AFFILIATIONS

Affiliated Faculty - Northeastern Institute for Experiential AI	**2021-present**
Affiliated Faculty - Northeastern Global Resilience Institute	**2018-present**
Affiliated Faculty - Northeastern Kostas Research Institute	**2017-present**
Visiting Professor - University of Rome La Sapienza, Italy	**2013-present**
Visiting Professor - University of Rome Tor Vergata, Italy	**Fall 2013**
Air Force Research Laboratory, Rome, NY - Visiting Faculty	**May-July 2010**

PUBLICATIONS

The current total number of citations (according to the Google Scholar Citation Index) is 25,327, the h-index is 65, and the i-10 index is 226.

Journals (published on arxiv or under review)

1. D. Villa, I. Khan, F. Kaltenberger, N. Hedberg, R. Soares da Silva, S. Maxenti, L. Bonati, A. Kelkar, C. Dick, E. Baena, J. M. Jornet, T. Melodia, M. Polese, and D. Koutsonikolas, "X5G: An Open, Programmable, Multi-vendor, End-to-end, Private 5G O-RAN Testbed with NVIDIA ARC and OpenAirInterface," June 2024.
2. P. Brach Del Prever, S. D'Oro, L. Bonati, M. Polese, M. Tsampazi, H. Lehmann, "PACIFISTA: Conflict Evaluation and Management in Open RAN," submitted to IEEE Transactions on Mobile Computing, 2024.
3. K. Alam, M. A. Habibi , M. Tammen, D. Krummacker, W. Saad, M. Di Renzo, T. Melodia, X. Costa-Perez, M. Debbah, A. Dutta, and H. D. Schotten "A Comprehensive Overview and Survey of O-RAN: Exploring Slicing-aware Architecture, Deployment Options, and Use Cases," submitted for publication, 2024.
4. C. Robinson, D. Uvaydov, S. D'Oro, T. Melodia, "DeepSweep: Adversarial Signal Detection over WiFi Utilizing Spectrum Sensing Techniques," submitted for publication, 2022.
5. F. Restuccia, S. D'Oro, S.S. Kanhere, T. Melodia, and S.K. Das, "Blockchain for the Internet of Things: Present and Future," arxiv, 2019.
6. R. Guida, T. Melodia, "Powering Smart Wireless Implantable Medical Devices," submitted to Ad Hoc Networks, 2024.

Journals and Magazines

7. A. Al-Shawabka, P. Pietraski, S. Pattar, P. Johari, T. Melodia, "SignCRF: Scalable Channel-Agnostic Data-Driven Radio Authentication System," IEEE Transactions on Mobile Computing, 2025.
8. M. Tsampazi, S. D'Oro, M. Polese, L. Bonati, G. Poitau, M. Healy, M. Alavirad, T. Melodia, "PandORA: Automated Design and Large-scale Evaluation of Deep Reinforcement Learning Agents for Open RAN," in IEEE Transactions on Mobile Computing, 2024.
9. D. Bodet, J. Hall, A. Masihi, N. Thawdar, T. Melodia, F. Restuccia, J. M. Jornet, "Data Signals for Deep Learning Applications in Terahertz Communications," Computer Networks, vol. 254, Dec. 2024.
10. J. Groen, S. D'Oro, U. Demir, L. Bonati, M. Polese, T. Melodia, K. Chowdhury, "Implementing and Evaluating Security in O-RAN: Interfaces, Intelligence, and Platforms," IEEE Network Magazine, 2024.

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11. M. Polese, L. Bonati, S. DOro, P. Johari, D. Villa, S. Velumani, R. Gangula, M. Tsampazi, C. Robinson, G. Gemmi, A. Lacava, S. Maxenti, H. Cheng, and T. Melodia, "Colosseum: The Open RAN Digital Twin," IEEE Open Journal of the Communications Society, April 2024.
12. P. Testolina, M. Polese, T. Melodia, "Sharing Spectrum and Services in the 7-24 GHz Upper Midband," IEEE Communications Magazine, 2024.
13. D. Unal, S. Falleni, K. Enhos, E. Demirors, S. Basagni, T. Melodia, "Design and Performance Evaluation of SEANet, a Software-defined Networking Platform for the Internet of Underwater Things," Computer Networks, 2024.
14. J. Groen, S. D'Oro, U. Demir, L. Bonati, D. Villa, M. Polese, T. Melodia, K. Chowdhury, "Securing O-RAN Open Interfaces," IEEE Transactions on Mobile Computing, 2024.
15. J. Neimat, R. Bina, S. Koenig, E. Demirors, R. Guida, R. Burke, T. Melodia, J. Jimenez, "A Novel Closed-Loop Electrical Brain Stimulation Device Featuring Wireless Low-Energy Ultrasound Power and Communication," Neuromodulation: Technology at the Neural Interface, May 2024.
16. L. Bonati, M. Polese, S. D'Oro, P. Brach del Prever, T. Melodia, "5G-CT: Automated Deployment and Over-the-Air Testing of End-to-End Open Radio Access Networks," IEEE Communications Magazine, 2024.
17. P. Testolina, M. Polese, J. Jornet, T. Melodia, M. Zorzi, "Modeling Interference for the Coexistence of 6G and Passive Sensing Systems," IEEE Transactions on Wireless Communications, 2024.
18. M. Polese, M. Dohler, F. Dressler, M. Erol-Kantarci, R. Jana, R. Knopp, T. Melodia, "Empowering the 6G Cellular Architecture with Open RAN," IEEE Journal on Selected Areas in Communications, Feb. 2024.
19. D. Villa, M. Tehrani-Moayyed, C. Robinson, L. Bonati, P. Johari, M. Polese, T. Melodia, "Colosseum as a Digital Twin: Bridging Real-World Experimentation and Wireless Network Emulation," IEEE Transactions on Mobile Computing, 2024.
20. S. D'Oro, L. Bonati, M. Polese, T. Melodia, "OrchestRAN: Orchestrating Network Intelligence in the Open RAN," IEEE Transactions on Mobile Computing, 2023.
21. L. Bonati, M. Polese, S. D'Oro, S. Basagni, and T. Melodia, "NeutRAN: An Open RAN Neutral Host Architecture for Zero-Touch RAN and Spectrum Sharing," IEEE Transactions on Mobile Computing, 2023.
22. M. Polese, X. Cantos-Roman, A. Singh, M. J Marcus, T. J Maccarone, T. Melodia, J. M Jornet "Coexistence and Spectrum Sharing Above 100 GHz," Proceedings of the IEEE, Proceedings of the IEEE, Vol. 111, No. 8, Aug. 2023.
23. A. Lacava, M. Polese, R. Sivaraj, R. Soundrarajan, B. S. Bhati, T. Singh, T. Zugno, F. Cuomo, T. Melodia, "Programmable and Customized Intelligence for Traffic Steering in 5G Networks Using Open RAN Architectures," IEEE Transactions on Mobile Computing, 2023.
24. M. Polese, L. Bonati, S. D'Oro, S. Basagni, T. Melodia, "Understanding O-RAN: Architecture, Interfaces, Algorithms, Security, and Research Challenges," IEEE Communications Surveys and Tutorials, 2023.
25. J. Hall, N. Thawdar, T. Melodia, J. Jornet, F. Restuccia, "Deep Learning at the Physical Layer for Adaptive Terahertz Communications," IEEE Transactions on Terahertz Science and Technology, 2023.
26. M. Polese, L. Bonati, S. D'Oro, S. Basagni, T. Melodia, "ColO-RAN: Developing Machine Learning-based xApps for Open RAN Closed-loop Control on Programmable Experimental Platforms," IEEE Transactions on Mobile Computing, vol. 22, no. 10, pp. 5787-5800, Oct. 2023.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000186

27. L. Bertizzolo, T. X. Tran, J. Buczek, B. Balasubramanian, Y. Zhou, R. Jana, and T. Melodia, "Streaming from the Air: Enabling Drone-sourced Video Streaming Applications on 5G Open-RAN Architectures," IEEE Transactions on Mobile Computing, vol. 22, no. 5, pp. 3004-3016, May 2023.
28. L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "OpenRAN Gym: AI/ML Development, Data Collection, and Testing for O-RAN on PAWR Platforms," Computer Networks, vol. 220, Jan. 2023.
29. L. Ferranti, S. D'Oro, L. Bonati, F. Cuomo, T. Melodia, "HIRO-NET: Heterogeneous Intelligent RObotic Network for Internet sharing in Disaster Scenarios," IEEE Transactions on Mobile Computing, vol. 21, no. 12, Dec. 2022.
30. K. Enhos, D. Unal, E. Demirors and T. Melodia, "Breaking Through the Air-Water Interface with Software-Defined Visible Light Networking," IEEE Internet of Things Magazine, vol. 5, no. 4, 2022.
31. B. Azari, H. Cheng, N. Soltani, H. Li, Y. Li, M. Belgiovine, T. Imbiriba, S. DOro, T. Melodia, Y. Wang, P. Closas, K. Chowdhury, D. Erdogmuz, "Automated Deep Learning-based Wideband Receiver," Computer Networks, vol. 218, Dec. 2022.
32. S. D'Oro, M. Polese, L. Bonati, H. Cheng, and T. Melodia, "dApps: Distributed Applications for Real-time Inference and Control in O-RAN," IEEE Communications Magazine, vo. 60, no. 11, Nov. 2022.
33. N. Soltani, H. Cheng, M. Belgiovine, Y. Li, H. Li, B. Azari, S. D'Oro, T. Imbiriba, T. Melodia, P. Closas, Y. Wang, D. Erdogmus, K. Chowdhury "Neural Network-based OFDM Receiver for Resource Constrained IoT Devices," IEEE Internet of Things Magazine, vol 5, no. 3, pp. 158-164, 2022.
34. F. Restuccia, S. DOro, A. Al-Shawabka, B. Costa Rendon, K. Chowdhury, S. Ioannidis, and T. Melodia, "Generalized Wireless Adversarial Deep Learning," Computer Networks, vol. 216, no. 24, Oct. 2022.
35. N. Cen, Z. Guan, T. Melodia, "Compressed Sensing based Low-Power Multi-view Video Coding and Transmission in Wireless Multi-path Multi-hop Networks," IEEE Transactions on Mobile Computing, vol. 21, no. 9, pp. 3122-3137, Sep. 2022.
36. F. Restuccia, T. Melodia, "Polymorphic Wireless Receivers," Communications of the ACM, vol. 65, no. 9, pp 83-91, Sep. 2022.
37. M. Polese, V. Ariyarathna, P. Sen, J. V. Siles, F. Restuccia, T. Melodia, J. M. Jornet, "Dynamic spectrum sharing between active and passive users above 100GHz," Nature Communications Engineering vol. 1, no. 6, May 2022.
38. R. Guida, E. Demirors, N. Dave, T. Melodia, "Underwater Ultrasonic Wireless Power Transfer: A Battery-less Platform for the Internet of Underwater Things," IEEE Transactions on Mobile Computing, vol. 21, no. 5, May 2022.
39. A. Jagannath, J. Jagannath, T. Melodia, "Redefining Wireless Communication for 6G: Signal Processing Meets Deep Learning with Deep Unfolding," IEEE Transactions on Artificial Intelligence, vol. 2, no. 6, pp. 528-536, Dec. 2021.
40. L. Bonati, S. D'Oro, M. Polese, S. Basagni, and T. Melodia, "Intelligence and Learning in O-RAN for Data-driven NextG Cellular Networks," IEEE Communications Magazine, vol. 59, no. 10, pp. 21-27, Oct. 2021.
41. F. Restuccia, S. D'Oro, A. Al-Shawabka, B. Costa Rendon, S. Ioannidis, and T. Melodia, "DeepFIR: Channel-Robust Physical-Layer Deep Learning Through Adaptive Waveform Filtering," IEEE Transactions on Wireless Communications, vol. 20, no. 12, pp. 8054-8066, Dec. 2021.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000187

42. H. Cheng, L. Bertizzolo, S. D'Oro, J. Buczek, T. Melodia, and E. S. Bentley, "Learning to Fly: A Distributed Deep-Reinforcement Learning Framework for Software-Defined UAV Network Control," IEEE Open Journal of the Communications Society, 2021.
43. F. Restuccia, T. Melodia, "Toward Polymorphic Internet of Things Receivers Through Real-Time Waveform-Level Deep Learning, " ACM GetMobile: Mobile Computing and Communications, vol. 25, no. 3, pp 2833, Sep. 2021.
44. S. D'Oro, L. Bonati, F. Restuccia and T. Melodia, "Coordinated 5G Network Slicing: How Constructive Interference Can Boost Network Throughput," IEEE/ACM Transactions on Networking, vol. 29, no.4, pp 1881-1894, Aug. 2021.
45. Z. Guan, H. Kulhandjian, and T. Melodia "Distributed Channel Access through Stochastic Interference Modeling for Underwater Acoustic Networks" *IEEE Transactions on Mobile Computing*, vol. 20, no. 8 pp. 3020-3033, Oct. 2021.
46. Z. Guan, L. Bertizzolo, E. Demirors, T. Melodia "WNOS: Enabling Principled Software-Defined Wireless Networking," IEEE/ACM Transactions on Networking, vol. 29, no. 3, pp. 1391-1407 June 2021.
47. R. Guida, N. Dave, F. Restuccia, E. Demirors, and T. Melodia, "The Implantable Internet of Medical Things: Toward Lifelong Remote Monitoring and Treatment of Chronic Diseases," ACM GetMobile, vol. 24, no. 3, Sept. 2020.
48. F. Restuccia and T. Melodia, "Deep Learning at the Physical Layer: System Challenges and Applications to 5G and Beyond," IEEE Communications Magazine, vol. 58, no. 10, Oct. 2020.
49. A. Al-shawabka, F. Restuccia, S. D'Oro, T.Melodia, "Massive-Scale I/Q Datasets for WiFi Radio Fingerprinting," Computer Networks, Vol. 182, December 2020.
50. M. Polese, J. Jornet, T. Melodia, M. Zorzi, "Towards End-to-End, Full-Stack 6G Terahertz Networks," IEEE Communications Magazine, vol. 58, no. 11, Nov. 2020.
51. L. Bonati, S. D'Oro, Z. Guan, S. Basagni, T. Melodia, "CellOS: Zero-touch Softwarized Cellular Networks," Computer Networks, 2020.
52. L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "Open, Programmable, and Virtualized 5G Networks: State-of-the-Art and the Road Ahead," Computer Networks, 2020.
53. L. Bertizzolo, L. Bonati, E. Demirors, A. Al-Shawabka, S. D'Oro, F. Restuccia, and T. Melodia, "Arena: A 64-antenna SDR-based Ceiling Grid Testing Platform for Sub-6 GHz 5G-and-Beyond Radio Spectrum Research," Computer Networks, 2020.
54. Z. Guan, N. Cen, T. Melodia, S. Pudlewski, "Distributed Joint Power, Association and Flight Control for Massive-MIMO Self-Organizing Flying Drones," IEEE/ACM Transactions on Networking, vol. 28, no. 4, pp. 1491-1505, Aug. 2020.
55. S. D'Oro, F. Restuccia, T. Melodia, "Toward Operator-to-Waveform 5G Radio Access Network Slicing," IEEE Communications Magazine, April 2020.
56. J. Jagannath, N. Polosky, A. Jagannath, F. Restuccia, T. Melodia, "Machine Learning for Wireless Communications in the Internet of Things: A Comprehensive Survey," Ad Hoc Networks (Elsevier), vol. 93, pp. 101-913, 2019. **MOST DOWNLOADED PAPER**
57. E. Santagati, N. Dave T. Melodia, "Design and Performance Evaluation of an Implantable Ultrasonic Networking Platform for the Internet of Medical Things," IEEE/ACM Transactions on Networking, vol. 29, no. 1, pp. 29-42, Feb. 2020.
58. K. Sankhe, M. Belgiovine, F. Zhou, L. Angioloni, F. Restuccia, S. DOro, T. Melodia, S. Ioannidis, and K. Chowdhury, "No Radio Left Behind: Radio Fingerprinting Through Deep Learning of Physical-Layer Hardware Impairments," in IEEE Transactions on Cognitive Communications and Networking, 2019.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000188

59. J. Jagannath, S. Furman, T. Melodia, A. Drozd, "Design and Experimental Evaluation of a Cross-Layer Deadline-Based Joint Routing and Spectrum Allocation Algorithm," IEEE Transactions on Mobile Computing, vol. 18, no. 8, pp. 1774-1788, August 2019.
60. S. D'Oro, F. Restuccia, T. Melodia, S. Palazzo, "Low-Complexity Distributed 5G Network Slicing: Analysis, Algorithms, and Experimental Results," IEEE/ACM Transactions on Networking, vol. 26, no. 6, pp. 2815-2828 Dec. 2018.
61. L. Zhang, F. Restuccia, T. Melodia, S. Pudlewski, "Taming Cross-Layer Attacks in Wireless Networks: A Bayesian Learning Approach," IEEE Transactions on Mobile Computing, vol. 18, no. 7, pp 1688-1702, July 2019.
62. S. Colonnese, F. Cuomo, L. Chiaraviglio, V. Salvatore, T. Melodia, I. Rubin, "CLEVER: a Cooperative and Cross-Layer Approach to Video Streaming in HetNets," IEEE Transactions on Mobile Computing, vol. 17, no. 7, July 2018.
63. F. Restuccia, S. D'Oro, T. Melodia, "Securing the Internet of Things in the Age of Machine Learning and Software-defined Networking," IEEE Internet of Things Journal, 2018.
64. N. Cen, J. Jagannath, S. Moretti, Z. Guan, T. Melodia "LANET: Visible-light Ad Hoc Networks," Ad Hoc Networks (Elsevier), 2018.
65. L. Ferranti, F. Cuomo, S. Colonnese, T. Melodia, "Drone Cellular Networks: Enhancing the Quality of Experience of Video Streaming Applications," Ad Hoc Networks (Elsevier), 2018, in press.
66. E. Demirors, G. Sklivanitis, G. Santagati, T. Melodia, S. Batalama "A High-Rate Software-Defined Underwater Acoustic Modem with Real-Time Adaptation Capabilities," IEEE Access, 2018.
67. F. Restuccia, N. Ghosh, S. Bhattacharjee, S. Das, T. Melodia, "Quality of Information in Mobile Crowdsensing," ACM Transactions on Sensor Networks, vol. 13, no.4, December 2017.
68. M. Hooshmand, D. Zordan, T. Melodia, M. Rossi, "SURF: subject-adaptive unsupervised ECG signal compression for wearable fitness monitors," IEEE Access, September 2017.
69. Z. Guan, T. Melodia, "The Value of Cooperation: Minimizing User Costs in Multi-broker Mobile Cloud Computing Networks," IEEE Transactions on Cloud Computing, vol. 5, no. 4, pp. 780-791, Oct-Dec 2017.
70. N. Cen, Z. Guan, T. Melodia, "Interview Motion Compensated Joint Decoding of Compressive-Sampled Multi-view Video Streaming," IEEE Transactions on Multimedia, vol. 19, no. 6, pp. 1117-1126, June 2017.
71. S. Colonnese, F. Cuomo, T. Melodia, I. Rubin, "A Cross-Layer Bandwidth Allocation Scheme for HTTP-based Video Streaming in LTE Cellular Networks," IEEE Communications Letters, vol. 21, no. 2, Feb. 2017.
72. G. Santagati, T. Melodia, "A Software-Defined Ultrasonic Networking Framework for Wearable Devices," IEEE/ACM Transactions on Networking, vol. 25, no. 2, pp. 960-973, Apr. 2017.
73. G. Santagati, T. Melodia, "Experimental Evaluation of Impulsive Ultrasonic Intra-Body Communications for Implantable Biomedical Devices," IEEE Transactions on Mobile Computing, vol. 16, no. 2, pp. 367-380, Feb. 2017.
74. Z. Guan, G. E. Santagati, T. Melodia, "Distributed Algorithms For Joint Channel Access and Rate Control in Ultrasonic Intra-body Networks," *IEEE/ACM Transactions on Networking*, vol. 24, no. 5, pp. 3109-3122, Oct. 2016.
75. L. Zhang, Z. Guan, T. Melodia, "United Against the Enemy: Anti-jamming Based on Cross-layer Cooperation in Wireless Networks," IEEE Transactions on Wireless Communications, vol. 15, no. 8, pp. 5733-5747, Aug. 2016.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000189

76. Z. Guan, T. Melodia, D. Yuan, D. Pados, "Distributed Resource Management for Cognitive Ad Hoc Networks with Cooperative Relays," *IEEE/ACM Transactions on Networking*, vol. 24, no. 3, pp. 1675-1689, June 2016.
77. Z. Guan, T. Melodia, G. Scutari, "To Transmit or Not to Transmit? Distributed Queueing Games for Infrastructureless Wireless Networks," *IEEE/ACM Transactions on Networking,* Vol. 24, no. 2, pp. 1153-1166, April 2016.
78. S. Colonnese, S. Russo, F. Cuomo, T. Melodia, I. Rubin, "Timely delivery versus bandwidth allocation for DASH based video streaming over LTE," IEEE Communications Letters, Vol. 20, no. 3, pp. 586-589, March 2016.
79. D. Zordan, T. Melodia, M. Rossi, "On the Design of Temporal Compression Strategies for Energy Harvesting Sensor Networks," *IEEE Transactions on Wireless Communications*, Vol. 15, no. 2, pp. 1336-1352, Feb. 2016.
80. H. Kulhandjian, T. Melodia, D. Koutsonikolas "CDMA-based Analog Network Coding for Underwater Acoustic Sensor Networks," *IEEE Transactions on Wireless Communications*, vol. 14, no. 11, pp. 6495 - 6507, November 2015.
81. E. Demirors, G. Sklivanitis, T. Melodia, S. Batalama, D. Pados, "Software-defined Underwater Acoustic Networks: Towards a High-rate Real-time Reconfigurable Modem," IEEE Communications Magazine, vol. 53, no. 11, pp. 64 - 71, November 2015.
82. G. Santagati, T. Melodia, L. Galluccio, S. Palazzo "Medium Access Control and Rate Adaptation for Ultrasonic Intra-Body Sensor Networks," *IEEE/ACM Transactions on Networking*, vol. 23, no. 4, pp. 1121-1134, August 2015.
83. L. Ding, T. Melodia, S. Batalama, J. Matyjas "Distributed Resource Allocation in Cognitive and Cooperative Ad Hoc Networks through Joint Routing, Relay Selection and Spectrum Allocation," *Computer Networks (Elsevier)*, no. 83, pp. 315-331, June 2015.
84. S. Pudlewski, N. Cen, Z. Guan, and T. Melodia "Video Transmission over Lossy Wireless Networks: A Cross-layer Perspective," *IEEE Journal of Selected Topics in Signal Processing*, vol. 9, no. 1, pp 6-22, February 2015.
85. S. Colonnese, F. Cuomo, R. Guida, T. Melodia, "Performance evaluation of sender-assisted HTTP-based video streaming in wireless ad hoc networks," Ad Hoc Networks (Elsevier), vol. 24, Part B, pp. 74-84, January 2015.
86. Z. Guan and T. Melodia "Cloud-assisted Smart-camera Networks for Energy-efficient 3D Video Streaming," *IEEE Computer*, vol. 47, no. 5, pp. 60-66, May 2014.
87. G. Santagati, T. Melodia, "Opto-Ultrasonic Communications for Wireless Intra-Body Nanonetworks," *Nano Communication Networks (Elsevier)*, vol. 5, no. 117, March-June 2014.
88. S. Pudlewski, T. Melodia, "Compressive Video Streaming: Design and Rate-Energy-Distortion Analysis," *IEEE Transactions on Multimedia*, vol. 8, no. 15, pp. 2072- 2084, December 2013.
89. S. Colonnese, F. Cuomo, T. Melodia, "An Empirical Model of Multiview Video Coding in Wireless Multimedia Sensor Networks," *IEEE Transactions on Multimedia*, vol. 8, no. 15, pp. 1800-1814, December 2013.
90. L. Ding, K. Gao, T. Melodia, S. Batalama, D. Pados, J. Matyjas, "All-spectrum Cognitive Networking through Jointly Optimal Distributed Channelization and Routing," IEEE Transactions on Wireless Communications, vol. 12, no. 11, pp. 5394-5405, November 2013.
91. G. E. Santagati, T. Melodia, L. Galluccio, S. Palazzo "Ultrasonic Networking for E-health Applications," *IEEE Wireless Communications Magazine*, vol. 20, no. 4, pp. 74-81, August 2013.
92. Z. Guan, T. Melodia, D. Yuan, "Jointly Optimal Rate Control and Relay Selection for Cooperative Video Streaming in Wireless Networks," *IEEE/ACM Transactions on Networking*, vol. 21, no. 4, pp. 1173-1186, August 2013.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000190

93. S. Pudlewski, T. Melodia, "A Tutorial on Encoding and Wireless Transmission of Compressively Sampled Videos," *IEEE Communications Surveys and Tutorials*, vol. 15, no. 2, pp. 754-767, 2013.

94. A. Guvensan, C. Taysi, T. Melodia, "Energy Monitoring in Residential Spaces with Audio Sensor Nodes: TinyEARS," *Ad Hoc Networks (Elsevier)*, vol. 11, no. 5, pp. 1539-1555, July 2013.

95. K. Gao, O. Ozdemir, S. Batalama, D. Pados, T. Melodia, A. Drozd, "Cognitive Code-Division Channelization with Admission Control," *Computer Networks and Communications (Hindawi)*, vol. 2012, Article ID 510942, 9 pages, 2012.

96. S. Pudlewski, T. Melodia, A. Prasanna "Compressed-Sensing-Enabled Video Streaming for Wireless Multimedia Sensor Networks," *IEEE Transactions on Mobile Computing*, vol.11, no.6, pp.1060-1072, June 2012.

97. M. Li, S. N. Batalama, D. Pados, T. Melodia, M. Medley, J. Matyjas, "Cognitive Code-Division Links with Blind Primary-System Identification," *IEEE Transactions on Wireless Communications*, vol. 10, no. 11, pp. 3743-3753, November 2011.

98. L.-C. Kuo, T. Melodia, "Distributed Medium Access Control Strategies for MIMO Underwater Acoustic Networking," *IEEE Transactions on Wireless Communications*, vol. 10, no. 8, pp. 2523-2533, August 2011.

99. K. Chowdhury, T. Melodia, "Platforms and Testbeds for Experimental Evaluation of Cognitive Ad Hoc Networks", *IEEE Communications Magazine*, vol. 48, no. 9, pp. 96-104, September 2010.

100. D. Pompili, T. Melodia, and I. F. Akyildiz, "Distributed Routing Algorithms for Underwater Acoustic Sensor Networks," *IEEE Transactions on Wireless Communications*, vol. 9, no. 9, September 2010.

101. S. Pudlewski, T. Melodia, "A Distortion Minimizing Rate Controller for Wireless Multimedia Sensor Networks," *Computer Communications (Elsevier)*, Vol. 33, no. 12, pp. 1380-1390, July 2010.

102. A. Zhang, Q. Zhang, T. Melodia, "A Frequency-domain Entropy-Based Spectrum Detector for Cognitive Radio Networks," *IEEE Communications Letters*, vol. 14, no. 6, pp. 533-535, July 2010.

103. T. Melodia, I. F. Akyildiz, "Cross-layer QoS-Aware Communication for Ultra Wide Band Wireless Multimedia Sensor Networks," in *IEEE Journal of Selected Areas in Communications*, vol. 28, no. 5, pp. 653-663, June 2010.

104. L. Ding, T. Melodia, S. Batalama, J. Matyjas and M. Medley, "Cross-layer Routing and Dynamic Spectrum Allocation in Cognitive Radio Ad Hoc Networks," *IEEE Transactions on Vehicular Technology*, vol. 59, no. 4, pp. 1969 - 1979, May 2010.

105. T. Melodia, W. Heinzelmann, "Cross-layer Optimization in Video Sensor Networks," *IEEE COMSOC MMTC E-Letter*, vol. 5, no. 3, May 2010.

106. T. Melodia, D. Pompili, and I. F. Akyildiz, "Handling Mobility in Wireless Sensor and Actor Networks," *IEEE Transactions on Mobile Computing*, vol. 9 no. 2, pp. 160-173, February 2010.

107. T. Melodia, S. Pudlewski, "A Case for Compressive Video Streaming in Wireless Multimedia Sensor Networks," *IEEE COMSOC MMTC E-Letter*, Vol. 4, No. 9, October 2009.

108. D. Pompili, T. Melodia, and I. F. Akyildiz, "A CDMA-based Medium Access Control for Underwater Acoustic Sensor Networks," *IEEE Transactions on Wireless Communications*, vol. 8 no.4, pp. 1899-1909, April 2009.

109. D. Pompili, T. Melodia, and I. F. Akyildiz, "Three-dimensional and Two-dimensional Deployment Analysis for Underwater Acoustic Sensor Networks," *Ad Hoc Networks (Elsevier)*, vol. 7, no. 4, pp. 778-790, June 2009 **Most Cited Article Award from Elsevier**.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000191

110. I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, "Wireless Multimedia Sensor Networks: Applications and Testbeds (Invited Paper)," *Proceedings of the IEEE*, Vol. 96, No. 10. (2008), pp. 1588-1605.

111. I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, "Wireless Multimedia Sensor Networks: A Survey," *IEEE Wireless Communications Magazine*, vol. 14, no. 6, pp. 32-39, December 2007.

112. T. Melodia, D. Pompili, V. C. Gungor, and I. F. Akyildiz, "Communication and Coordination in Wireless Sensor and Actor Networks," *IEEE Transactions on Mobile Computing*, vol. 6, no. 10, pp. 1116–1129, October 2007.

113. I. F. Akyildiz, D. Pompili, and T. Melodia, "State of the Art in Protocol Research for Underwater Acoustic Sensor Networks," *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 11, no. 4 October 2007.

114. I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, "A Survey on Wireless Multimedia Sensor Networks," *Computer Networks (Elsevier) Journal*, vol. 51, no. 4, pp. 921–960, March 2007 **ISI Essential Science Indicator Thomson Reuters FAST BREAKING PAPER IN COMPUTER SCIENCE**.

115. U. Monaco, F. Cuomo, T. Melodia, F. Ricciato, and M. Borghini, "Understanding Optimal Data Gathering in the Energy and Latency Domains of a Wireless Sensor Network," *Computer Networks (Elsevier) Journal*, vol. 50, no. 18, pp. 3564–3584, December 2006.

116. I. F. Akyildiz, D. Pompili, and T. Melodia, "Underwater Acoustic Sensor Networks: Research Challenges," *Ad Hoc Networks (Elsevier) Journal*, vol. 3, no. 3, pp. 257–279, May 2005 **ELSEVIER TOP CITED PAPER AWARD**.

117. T. Melodia, D. Pompili, and I. F. Akyildiz, "On the Interdependence of Distributed Topology Control and Geographical Routing in Ad Hoc and Sensor Networks," *IEEE Journal of Selected Areas in Communications (JSAC)*, vol. 23, no. 3, pp. 520–532, Mar. 2005.

118. F. Cuomo, T. Melodia, and I. F. Akyildiz, "Distributed Self-healing and Variable Topology Optimization Algorithms for QoS Provisioning in Scatternets," *IEEE Journal of Selected Areas in Communications (JSAC)*, vol. 22, no. 7, pp. 1220–1236, September 2004.

119. I. F. Akyildiz, D. Pompili, and T. Melodia, "Challenges for Efficient Communication in Underwater Acoustic Sensor Networks (Invited Paper)," *ACM Sigbed Review*, vol. 1, no. 2, July 2004.

120. T. Melodia and F. Cuomo, "Ad Hoc Networking with Bluetooth: Key Metrics and Distributed Protocols for Scatternet Formation," *Ad Hoc Networks (Elsevier) Journal*, vol. 2, no. 2, pp. 185–202, April 2004.

Conferences and Workshops

121. D. Uvaydov, S. D'Oro, T. Melodia, "AutoPilot: Steering OFDM Pilots Away From Jamming Using Deep Learning," in Proc. of Intl. Conf. on Computing, Networking and Communications (ICNC), Honolulu, HI, Feb. 2025.

122. C. Robinson, A. Lacava, P. Johari, F. Cuomo, T. Melodia, "TwiNet: Connecting Real World Networks to their Digital Twins Through a Live Bidirectional Link," in Proc. of IEEE Global Communications Conference (GLOBECOM), Cape Town, South Africa, December 2024. **BEST PAPER AWARD**

123. H. Cheng, S. D'Oro, R. Gangula, S. Velumani, D. Villa, L. Bonati, M. Polese, T. Melodia, G. Arrobo, and C. Maciocco, "ORANSlice: An Open Source 5G Network Slicing Platform for O-RAN," in Proc. of ACM Workshop on Open AI and Open RAN (Open AI RAN), Washington, DC, USA, November 2024.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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124. A. Feraudo, S. Maxenti, A. Lacava, P. Bellavista, M. Polese, T. Melodia, "xDevSM: Streamlining xApp Development With a Flexible Framework for O-RAN E2 Service Models," in Proc. of ACM Workshop on Wireless Network Testbeds, Experimental evaluation & CHaracterization (WiNTECH), Washington, DC, USA, November 2024.

125. L. Bonati, R. Shirkhani, C. Fiandrino, S. Maxenti, S. D'Oro, M. Polese, T. Melodia, "Twinning Commercial Network Traces on Experimental Open RAN Platforms," Proc. of ACM Workshop on Wireless Network Testbeds, Experimental evaluation & CHaracterization (WiNTECH), Washington, DC, USA, November 2024.

126. G. Gemmi, M. Polese, T. Melodia, L. Maccari, "Optimizing and Managing Wireless Backhaul for Resilient Next-Generation Cellular Networks," in Proc. of IEEE/IFIP Intl. Conf. on Network and Service Management (CNSM), Prague, Czech Republic, October 2024. **BEST PAPER AWARD**

127. A. Saeizadeh, M. Tehrani-Moayyed, D. Villa, J. G. Beattie, Jr., I. C. Wong, P. Johari, E. W. Anderson, S. Basagni, T. Melodia, "AI-assisted Agile Propagation Modeling for Real-time Digital Twin Wireless Networks," in Proc. of IEEE International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD), Athens, Greece, October 2024.

128. A. Saeizadeh, P. Brach del Prever, D. Schonholtz, R. Guida, E. Demirors, J. M. Jimenez, P. Johari, T. Melodia, "Demo: Multi-Modal Seizure Prediction System," Proc. of IEEE 20th International Conference on Body Sensor Networks (BSN), Chicago, USA, October 2024.

129. A. Saeizadeh, D. Schonholtz, J. S. Neimat, P. Johari, T. Melodia, "A Multi-Modal Non-Invasive Deep Learning Framework for Progressive Prediction of Seizures," in Proc. of IEEE 20th International Conference on Body Sensor Networks (BSN), Chicago, USA, October 2024.

130. G. Gemmi, M. Polese, P. Johari, S. Maxenti, M. Seltser, and T. Melodia, "Open6G OTIC: A Blueprint for Programmable O-RAN and 3GPP Testing Infrastructure," in Proc. of IEEE Ritiran, September 2024.

131. P. Donnelly, K. Enhos, E. Demirors, J. M. Jornet, and T. Melodia, "OTFS for Mobile Underwater Acoustic Communications: Parameter Selection and Testing on Software-Defined Modems," in Proc. of the Underwater Communications and Networking Conference (UComms), Sestri Levante, Italy, Sept. 2024.

132. G. Gemmi, P. Johari, P. Casari, M. Polese, T. Melodia, and M. Segata, "ColosSUMO: Evaluating Cooperative Driving Applications with Colosseum," in Proc. of the IEEE Vehicular Networking Conference (VNC), Kobe, Japan, May 2024. **BEST SHORT PAPER AWARD**

133. P. Testolina, M. Polese, P. Johari, T. Melodia, "BostonTwin: the Boston Digital Twin for Ray-Tracing in 6G Networks," in Proc. of ACM Multimedia Systems Conf., Bari, Italy, April 2024.

134. C. Robinson, D. Uvaydov, S. D'Oro, T. Melodia, "DeepSweep: Parallel and Scalable Spectrum Sensing via Convolutional Neural Networks," IEEE Intl. Conf. on Machine Learning for Communication and Networking (ICMLCN), Stockholm, Sweden, June 2024.

135. D. Villa, I. Khan, F. Kaltenberger, N. Hedberg, R. Soares da Silva, A. Kelkar, C. Dick, S. Basagni, J. M. Jornet, T. Melodia, M. Polese, and D. Koutsonikolas, "An Open, Programmable, Multi-vendor 5G O-RAN Testbed with NVIDIA ARC and OpenAirInterface," Proc. of IEEE Work. on Next-generation Open and Programmable Radio Access Networks (NG-OPERA), Vancouver, BC, Canada, May 2024. **BEST PAPER RUNNER-UP AWARD**

136. S. Maxenti, S. D'Oro, L. Bonati, M. Polese, A. Capone, T. Melodia, "ScalO-RAN: Energy-aware Network Intelligence Scaling in Open RAN," Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2024.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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137. A. Scalingi, S. D'Oro, F. Restuccia, T. Melodia, D. Giustiniano, "Det-RAN: Data-Driven Cross-Layer Real-Time Attack Detection in 5G Open RANs," Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2024.

138. D. Uvaydov, M. Zhang, C. Robinson, S. D'Oro, T. Melodia and F. Restuccia, "Stitching the Spectrum: Semantic Spectrum Segmentation with Wideband Signal Stitching," Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2024.

139. R. Raftopoulos, S. D'Oro, T. Melodia and G. Schembra, "DRL-based Latency-Aware Network Slicing in O-RAN with Time-Varying SLAs," Proc. of Intl. Conf. on Computing, Networking, and Communication (ICNC), Big Island, Hawaii, February 2024.

140. A. Saeizadeh, D. Schonholtz, D. Uvaydov, R. Guida, E. Demirors, P. Johari, J. M. Jimenez, J. S. Neimat, T. Melodia, "SeizNet: An AI-Enabled Implantable Sensor Network System for Seizure Prediction," Proc. of IEEE/IFIP Wireless On-demand Network systems and Services Conference (WONS), Chamonix, France, January 2024.

141. H. Cheng, P. Johari, M. A. Arfaoui, F. Periard, P. Pietraski, G. Zhang, T. Melodia, "Real-Time AI-Enabled CSI Feedback Experimentation with Open RAN," Proc. of IEEE/IFIP Wireless On-demand Network systems and Services Conference (WONS), Chamonix, France, January 2024.

142. R.Mundlamuri, S. Badran, R. Gangula, F. Kaltenberger, J. Jornet, T. Melodia, "5G over Terahertz Using OpenAirInterface," in Proc. of. IEEE/IFIP Wireless On-demand Network systems and Services Conference (WONS), Chamonix, France, January 2024.

143. C. Fiandrino, L. Bonati, S. D'Oro, M. Polese, T. Melodia, and J. Widmer, "EXPLORA: AI/ML EXPLainability for the Open RAN," Proceedings of ACM Intl. Conf. on emerging Networking EXperiments and Technologies (CoNEXT)," Paris, France, December 2023.

144. G. Gemmi, M. Elkael, M. Polese, L. Maccari, H. Castel-Taleb, T. Melodia, "Joint Routing and Energy Optimization for Integrated Access and Backhaul networks with Open RAN," in Proc. of IEEE Global Communications Conf. (GLOBECOM), Kuala Lumpur, Malaysia, Dec. 2023.

145. M. Tsampazi, S. D'Oro, M. Polese, L. Bonati, G. Poitau, M. Healy, and T. Melodia, "A Comparative Analysis of Deep Reinforcement Learning-based xApps in O-RAN," Proceedings of IEEE Global Communications Conf. (GLOBECOM), Kuala Lumpur, Malaysia, December 2023.

146. E. Moro, M. Polese, A. Capone, and T. Melodia, "An Open RAN Framework for the Dynamic Control of 5G Service Level Agreements," Proc. of IEEE Conf. on Network Function Virtualization and Software Defined Networks (NFV-SDN'23), Dresden, Germany, Nov. 2023.

147. R. Gangula, O. Esrafilian, D. Gesbert, T. Melodia, "Localization in Wideband SIMO Channels Using Pulse Shape," in Proc. of Asilomar Conference on Signals, Systems, and Computers, Asilomar, CA, USA, Oct.-Nov. 2023.

148. K. Enhos, D. Unal, J. Turco, E. Demirors and T. Melodia, "MArena: SDR-based Testbed for Underwater Wireless Communication and Networking Research," in Proc. of ACM Work. on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH), Madrid, Spain, Oct. 2023.

149. D. Villa, D. Uvaydov, L. Bonati, P. Johari, J. M. Jornet, and T. Melodia, "Twinning Commercial Radio Waveforms in the Colosseum Wireless Network Emulator," in Proc. of ACM Work. on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH), Madrid, Spain, Oct. 2023.

150. A. Pinto, A. Ashdown, T. Hassan, H. Cheng, F. Esposito, L. Bonati, S. D'Oro, T. Melodia, and F. Restuccia, "An Emulation-Based Framework for Transport Layer Measurements over 5G Wireless Networks," in Proc. of ACM Work. on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH), Madrid, Spain, Oct. 2023.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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Page 000194

151. A. Mody, B. Crompton, D. Tran, D. Giger, D. Simpson, D. Gormley, A. Smith, M. Kappes, D. Redelings, T. Melodia, "CLAIRE: Enabling Heterogeneous Communication Network Optimization for Robust and Resilient Operations," in Proc. of IEEE Cognitive Communications for Aerospace Applications Workshop (CCAAW), June 2023.

152. A. Mody, J. Islam, B. Crompton, D. Tran, D. Simpson, D. Gormley, A. Smith, M. Kokar, J. Moskal, T. Melodia, "INSPiREAn Approach to Mission Quality Management using Network Slicing for Space Applications," in Proc. of IEEE Cognitive Communications for Aerospace Applications Workshop (CCAAW), June 2023.

153. A. Lacava, M. Bordin, M. Polese, R. Sivaraj, T. Zugno, F. Cuomo, T. Melodia, "ns-O-RAN: Simulating O-RAN 5G Systems in ns-3," Proceedings of the Workshop on ns-3 (WNS3), Arlington, VA, USA, June 2023.

154. E. Moro, G. Gemmi, M. Polese, L. Maccari, A. Capone, T. Melodia, "Toward Open Integrated Access and Backhaul with O-RAN," Proc. Of Mediterranean Communication and Computer Networking Conf. (MedComNet), Ponza, Italy, June 2023.

155. D. Unal, K. Enhos, E. Demirors and T. Melodia, "Experimental Evaluation of Forward Error Correction Techniques for High-Rate Underwater Acoustic Communication Systems," in Proc. of the Underwater Acoustics Conference and Exhibition (UACE), Kalamata, Greece, June 2023.

156. D. Uvaydov, D. Unal, K. Enhos, E. Demirors and T. Melodia, "Sonair: Real-Time Deep Learning For Underwater Acoustic Spectrum Sensing and Classification," in Proc. of IEEE International Conference on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT), Pafos, Cyprus, June 2023.

157. C. Robinson, D. Uvaydov, S. D'Oro, and T. Melodia, "Narrowband Interference detection via Deep Learning," in Proc. of IEEE Intl. Conf. on Computer Communications (ICC), Rome, Italy, May 2023.

158. K. Enhos, D. Unal, E. Demirors and T. Melodia, 'Software-Defined Distributed SIMO System for Underwater Communication," in IEEE International Conference on Communications (ICC), Rome, Italy, May 2023.

159. D. Unal, K. Enhos, E. Demirors and T. Melodia, "Field Experiments with Doppler Compensation in High-Frequency Underwater Acoustic Communication System," in Proc. of IEEE Intl. Conf. on Computer Communications (ICC), Rome, Italy, May 2023.

160. C. Robinson, L. Bonati, T. van Nieuwstadt, T. Reiss, P. Johari, M. Polese, H. Nguyen, C. Watson, T. Melodia, "eSWORD: Implementation of Wireless Jamming Attacks in a Real-World Emulated Network," IEEE Communications and Networking Conference (WCNC), Glasgow, Scotland, Mar. 2023.

161. S. Falleni, T. Melodia, and S. Basagni, "A Reservation-based Adaptive MAC Protocol for OFDM Physical Layers in Underwater Networks," In Proc. of Intl. Conf. onComputing, Networking and Communications (ICNC), Honolulu, HI, Feb. 2023.

162. S. Lin, M. Shi, A. Arora, R. Bassily, E. Bertino, C. Caramanis, K. Chowdhury, E. Ekici, A. Eryilmaz, S. Ioannidis, N. Jiang , G. Joshi, J. Kurose, Y. Liang, Z. Lin, J. Liu, M. Liu, T. Melodia, A. Mokhtari, R. Nowak, S. Oh, S. Parthasarathy, C. Peng, H. Seferoglu, N. Shroff, S. Shakkottai, K. Srinivassan, A. Talwalkar, A. Yener, L. Ying, "Leveraging Synergies Between AI and Networking to Build Next Generation Edge Networks," in IEEE Intl. Conf. on Collaboration and Internet Computing, Dec. 2022.

163. N. Neasamoni Santhi, M. Polese, T. Melodia, "An End-to-End Programmable Testbed for the Experimental Evaluation of Video Streaming at mmWaves," Proc. of the IEEE GLOBECOM Workshop on High Capacity Wireless Communications (HCWC), Rio de Janeiro, Brazil, Dec. 2022.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000195

164. M. Bordin, M. Giordani, M. Polese, T. Melodia, and M. Zorzi, "Autonomous Driving From the Sky: Design and End-to-End Performance Evaluation," in Proc. of IEEE GLOBECOM Work. on 6G Communication Systems (NetMan6G), Rio de Janeiro, Brazil, Dec. 2022.

165. K. Enhos, E. Demirors, D. Unal and T. Melodia, "Coexistence of Multi-Dimensional Chirp Spread Spectrum in Underwater Acoustic Networks," in Proc. of ACM Intl. Conf. on Underwater Networks and Systems (WUWNet), Boston, USA, November 2022.

166. P. Sen, J. Hall, M. Polese, V. Petrov, D. Bodet, F. Restuccia, T. Melodia, J. M. Jornet, "Terahertz Communications Can Work in Rain and Snow: Impact of Adverse Weather Conditions on Channels at 140 GHz," Proc. of ACM Workshop on Millimeter-Wave Networks and Sensing Systems (mmNets), Sidney, Australia, Oct. 2022.

167. D. Villa, M. Tehrani-Moayyed, P. Johari, S. Basagni, T. Melodia, "CaST: A Toolchain for Creating and Characterizing Realistic Wireless Network Emulation Scenarios," Proc. of ACM Workshop on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH), Sydney, Australia, Oct. 2022.

168. L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "Intelligent Closed-loop RAN Control with xApps in OpenRAN Gym," Proc. of European Wireless 2022, Dresden, Germany, Sep. 2022.

169. L. Colombo, L. Baldesi, M. Rinaldi and T. Melodia, "Neural Network-Aided Spurious Modes Optimization Targeting Lithium Niobate MEMS Resonators," in IEEE Intl. Microwave Symposium (IMS), Denver, Colorado, June 2022.

170. K. Enhos, E. Demirors, D. Unal and T. Melodia, "Modeling and Optimization of Visible Light Carrierless Amplitude and Phase Modulation Links," in Proc. of IEEE Intl. Conf. on Communications (ICC), Seoul, South Korea, May 2022.

171. D. Unal, S. Falleni, E. Demirors, K. Enhos, S. Basagni and T. Melodia, "Software-Defined Underwater Acoustic Networking Platform for Underwater Vehicles," in Proc. of IEEE Intl. Conf. on Communications (ICC), Seoul, South Korea, May 2022.

172. A. Jagannath, J. Jagannath, Y. Wang, T. Melodia, "Deep neural network goes lighter: A case study of deep compression techniques on automatic RF modulation recognition for Beyond 5G networks," in Proc. of SPIE Defense and Commercial Sensing, Orlando, Florida, USA, May 2022.

173. L. Bonati, M. Polese, S. D'Oro, S. Basagni, T. Melodia, "OpenRAN Gym: An Open Toolbox for Data Collection and Experimentation with AI in O-RAN," Proc. of IEEE WCNC Workshop on Open RAN Architecture for 5G Evolution and 6G, Austin, TX, USA, Apr. 2022.

174. L. Baldesi, F. Restuccia, T. Melodia, "ChARM: NextG Spectrum Sharing Through Data-Driven Real-Time O-RAN Dynamic Control," in Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Apr. 2022. **BEST PAPER AWARD**

175. S. D'Oro, L. Bonati, M. Polese, T. Melodia, "OrchestRAN: Network Automation through Orchestrated Intelligence in the Open RAN," in Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Apr. 2022.

176. D. Unal, S. Falleni, E. Demirors, K. Enhos, S. Basagni, T. Melodia, "Software-Defined Underwater Acoustic Networking for Unmanned Underwater Vehicles," IEEE ICC 2022.

177. D. Uvaydov, R. Guida, P. Johari, F. Restuccia, and T. Melodia, "AiEEG: Personalized Seizure Prediction Through Partially-Reconfigurable Deep Neural Networks," IEEE Conf. on Pervasive Computing and Communications (PerCom 2022), March 2022.

178. J. Buczek, L. Bertizzolo, S. Basagni, and T. Melodia "What is a Wireless UAV? A Design Blueprint for 6G Flying Wireless Nodes," In Proc. of ACM Workshop on Wireless Network Testbeds, Experimental evaluation and CHaracterization (WiNTECH), New Orleans, LA, Jan. 2022.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000196

179. B. Casasole, L. Bonati, S. DOro, S. Basagni, A. Capone, T. Melodia, "QCell: Self-optimization of Softwarized 5G Networks through Deep Q-learning," in Proc. of IEEE Global Conference on Communications (Globecom), Madrid, Spain, December 2021.

180. S. Falleni, D. Saha, I. Haque, T. Melodia, and S. Basagni, "Development and Testing of an OFDM Physical Layer for the DESERT Simulator," In Proc. of MTS/IEEE OCEANS 2021, Sep. 2021.

181. M. Polese, F. Restuccia, and T. Melodia, "DeepBeam: Deep Waveform Learning for Coordination-Free Beam Management in mmWave Networks," Proc. of ACM Intl. Symp. on Theory, Algorithmic Foundations, and Protocol Design for Mobile Networks and Mobile Computing (ACM MobiHoc), October 2021.

182. "L. Bonati, S. D'Oro, S. Basagni, and T. Melodia, "SCOPE: An Open and Softwarized Prototyping Platform for NextG Systems," in Proc. of ACM Intl. Conf. on Mobile Systems, Applications, and Services (MobiSys), Virtual Conference, June 2021.

183. M. Tehrani-Moayyed, L. Bonati, P. Johari, T. Melodia, and S. Basagni, "Creating RF Scenarios for Large-Scale, Real-Time Wireless Channel Emulators," in Proc. of Mediterranean Communication and Computer Networking Conference (MedComNet), June 2021.

184. L. Ghiro, F. Restuccia, S. D'Oro, S. Basagni, T. Melodia, L. Maccari, and R. Lo Cigno, "A Blockchain Definition to Clarify its Role for the Internet of Things," in Proc. of Mediterranean Communication and Computer Networking Conference (MedComNet), June 2021.

185. K. Enhos, E. Demirors, D. Unal, T. Melodia, "Software-Defined Visible Light Networking for Bi-Directional Wireless Communication Across the Air-Water Interface," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), June 2021.

186. L. Bonati, S. D'Oro, F. Restuccia, S. Basagni, and T. Melodia, "SteaLTE: Private 5G Cellular Connectivity as a Service with Full-stack Wireless Steganography," in Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2021.

187. S. D'Oro, F. Restuccia, and T. Melodia, "Can You Fix My Neural Network? Real-Time Adaptive Waveform Synthesis for Resilient Wireless Signal Classification," in Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2021.

188. D. Uvaydov, S. D'Oro, F. Restuccia, and T. Melodia, "DeepSense: Fast Wideband Spectrum Sensing Through Real-Time In-the-Loop Deep Learning," in Proc. of IEEE Intl. Conf. on Computer Communications (INFOCOM), Vancouver, BC, Canada, May 2021.

189. S. Falleni, D. Unal, A. Neerman, K. Enhos, E. Demirors, S. Basagni, and T. Melodia, "Design, Development, and Testing of a Smart Buoy for Underwater Testbeds in Shallow Waters," In Proc. of IEEE/MTS Global OCEANS 2020, Singapore-U.S. Gulf Coast, October 2020.

190. L. Ferranti, L. Bonati, S. D'Oro, T. Melodia, "SkyCell: A Prototyping Platform for 5G Aerial Base Stations," IEEE Workshop on Wireless Networking, Planning, and Computing for UAV Swarms, August 2020.

191. F. Restuccia, S. DOro, A. Al-Shawabka, B. Costa Rendon, K. Chowdhury, S. Ioannidis and T. Melodia, "Generalized Wireless Adversarial Deep Learning," ACM Workshop on Wireless Security and Machine Learning, July 2020.

192. F. Restuccia, T. Melodia, "PolymoRF: Polymorphic Wireless Receivers Through Physical-Layer Deep Learning," Proc. of ACM Intl. Symp. on Theory, Algorithmic Foundations, and Protocol Design for Mobile Networks and Mobile Computing (ACM MobiHoc), October 2020 (AR: 15%) **ACM Sigmobile Highlights Paper** .

193. S. DOro, L. Bonati, F. Restuccia, M. Polese, M. Zorzi, T. Melodia, "Sl-EDGE: Network Slicing at the Edge," Proc. of ACM Intl. Symp. on Theory, Algorithmic Foundations, and Protocol Design for Mobile Networks and Mobile Computing (ACM MobiHoc), October 2020 (AR: 15%).

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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194. L. Bertizzolo, S. D'Oro, L. Ferranti, L. Bonati, E. Demirors, Z. Guan, T. Melodia and S. Pudlewski "SwarmControl: An Automated Distributed Control Framework for Self-Optimizing Drone Networks," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Beijing, China, Apr. 2020 (AR: 20%).

195. L. Bertizzolo, E. Demirors, Z. Guan, and T. Melodia, "CoBeam: Beamforming-based Spectrum Sharing With Zero Cross-Technology Signaling for 5G Wireless Networks," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Beijing, China, Apr. 2020 (AR: 20%).

196. F. Restuccia and T. Melodia, "DeepWiERL: Bringing Deep Reinforcement Learning to the Internet of Self-Adaptive Things," IEEE International Conference on Computer Communications (IEEE INFOCOM), Beijing, China, April 2020 (AR: 20%).

197. A. Al-Shawabka, F. Restuccia, S. D'Oro, T. Jian, B. Costa Rendon, N. Soltani, J. Dy, K. Chowdhury, S. Ioannidis and T. Melodia, "Exposing the Fingerprint: Dissecting the Impact of the Wireless Channel on Radio Fingerprinting," to appear in Proceedings of IEEE International Conference on Computer Communications (IEEE INFOCOM), Beijing, China, April 2020 (AR: 20%).

198. L. Bertizzolo, T. X. Tran, B. Amento, B. Balasubramanian, R. Jana, H. Purdy, Y. Zhou and T. Melodia "Live and Let Live: Flying UAVs Without Affecting Terrestrial UEs," in Proc. of the ACM International Workshop on Mobile Computing Systems and Applications (HotMobile), Austin, TX, Mar. 2020 (AR: 33%).

199. R. Guida, N. Dave, F. Restuccia, E. Demirors, T. Melodia, "U-Verse: A Miniaturized Platform for End-to-End Closed-Loop Implantable Internet of Medical Things Systems," in Proc. of ACM Conf. on Embedded Networked Sensor Systems (SenSys 2019), New York, NY, November 2019.

200. K. Sankhe, F. Restuccia, S. D'Oro, T. Jian, Z. Wang, A. Al-Shawabka, J. Dy, T. Melodia, S. Ioannidis, and K. Chowdhury, "Impairment Shift Keying: Covert Signaling by Deep Learning of Controlled Radio Imperfections," in Proceedings of IEEE/AFCEA Military Communications Conference (MILCOM), Norfolk, VA, November 2019.

201. K. Zheng, A. Dhananjay, M. Mezzavilla, A. Madanayake, S. Bharadwaj, V. Ariyarathna, A. Gosain, T. Melodia, F. Restuccia. J. Jornet, M. Polese, M. Zorzi, J. Buckwalter, M. Rodwell, S. Mandal, and X. Wang, J. Haarla, V. Semkin, "Software-defined Radios to Accelerate mmWave Wireless Innovation," in Proc. of the IEEE Intl. Symp. on Dynamic Spectrum Access Networks Workshops (DySPAN), Newark, NJ, USA, 2019.

202. L. Bertizzolo, L. Bonati, E. Demirors, T. Melodia, "Arena: A 64-antenna SDR-based Ceiling Grid Testbed for Sub-6 GHz Radio Spectrum Research," ACM Workshop on Wireless Network Testbeds, Experimental evaluation & CHaracterization (WiNTECH 2019), Los Cabos, Mexico, October 2019 **BEST PAPER AWARD**.

203. E. Demirors, D. Unal, G. E. Santagati, and T. Melodia, "High-Data Rate Carrierless Impulsive Communications For Underwater Acoustic Networks, in Proc. of the Underwater Acoustics Conference Exhibition (UACE), Crete, Greece, July 2019.

204. L. Ferranti, S. D'Oro, L. Bonati, E. Demirors, F. Cuomo, T. Melodia, "HIRO-NET: Self-Organized Robotic Mesh Networking for Internet Sharing in Disaster Scenarios," in Proc. of IEEE Symp. on a World of Wireless, Mobile, and Multimedia Networks (WoWMoM), Washington D.C., USA, June 2019. **BEST PAPER AWARD**.

205. J. Jagannath, T. Melodia, "VL-ROUTE: A Cross-Layer Routing Protocol for Visible Light Ad Hoc Network," in Proc. of IEEE Symp. on a World of Wireless, Mobile, and Multimedia Networks (WoWMoM), Washington D.C., USA, June 2019.

206. L. Zhang, T. Melodia, S. Pudlewski, "Jam Sessions: Analysis and Experimental Evaluation of Advanced Jamming Attacks in MIMO Networks," in Proc. of ACM Intl. Symp. on Mobile Ad Hoc Networking and Computing (MobiHoc), Catania, Italy, July 2019, (AR: 23%).

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Page 000198

207. F. Restuccia, S. D'Oro, A. Al-Shawabka, M. Belgiovine, L. Angioloni, S. Ioannidis, K. Chowdhury, T. Melodia, "DeepRadioID: Real-Time Channel-Resilient Optimization of Deep Learning-based Radio Fingerprinting Algorithms," in Proc. of ACM Intl. Symp. on Mobile Ad Hoc Networking and Computing (MobiHoc), Catania, Italy, July 2019, (AR: 23%).

208. S. D'Oro, F. Restuccia, A. Talamonti, T. Melodia, "The Slice Is Served: Enforcing Radio Access Network Slicing in Virtualized 5G Systems," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Paris, France, April 2019 (AR: 19%).

209. F. Restuccia and T. Melodia, "Big Data Goes Small: Real-Time Spectrum-Driven Embedded Wireless Networking Through Deep Learning in the RF Loop," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Paris, France, May 2019 (AR: 19%).

210. S. D'Oro, F. Restuccia, T. Melodia, "Hiding Data in Plain Sight: Undetectable Wireless Communications Through Pseudo-Noise Asymmetric Shift Keying," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Paris, France, April 2019 (AR: 19%).

211. N. Cen, N. Dave, E. Demirors, Z. Guan, T. Melodia, "LiBeam: Throughput-Optimal Cooperative Beamforming for Indoor Visible Light Networks," in Proc. of IEEE Conference on Computer Communications (INFOCOM), Paris, France, April-May 2019 (AR: 19%).

212. F. V. Pop, B. Herrera, G. Chen, E. Demirors, R. Guida, C. Cassella, T. Melodia, and M. Rinaldi, "Novel pMUT-Based Acoustic Duplexer for Underwater and Intra-Body Communication," in Proc. of IEEE Intl. Ultrasonics Symposium (IUS), Kobe, Japan, October 2018.

213. E. Demirors, J. Shi, A. Duong, N. Dave, R. Guida, B. Herrera, F. Pop, G. Chen, C. Casella, S. Tadayon, M. Rinaldi, S. Basagni, M. Stojanovic and T. Melodia, "Project SEANet: Toward a Programmable Internet of Underwater Things," in Proc. of. IEEE Underwater Communications Conf. and Workshop (UComms), Lerici, Italy, August 2018.

214. R. Guida, E. Demirors, N. Dave, J. Rodowicz and T. Melodia, "Acoustically Powered Batteryless Internet of Underwater Things Platform," in Proc. of. IEEE Underwater Communications Conf. and Workshop (UComms), Lerici, Italy, August 2018.

215. J. Shi, E. Demirors, T. Melodia, "Towards Robust High Speed Underwater Acoustic Communications Using Chirp Multiplexing," in Proc. of IEEE Oceans 2018, Charleston, S.C., October 2018.

216. R. Guida, T. Melodia, "Ultrasonically Rechargeable Platforms for Closed-Loop Distributed Sensing and Actuation in the Human Body,"IEEE Intl. Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Kalamata, Greece, June 2018.

217. Z. Guan, N. Cen, T. Melodia, S. Pudlewski, " Self-Organizing Flying Drones with Massive MIMO Networking," in *Proc. of Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net)*, Capri, Italy, June 2018.

218. Z. Guan, L. Bertizzolo, E. Demirors, T. Melodia, "WNOS: An Optimization-based Wireless Network Operating System," in Proc. of ACM Intl. Symp. on Mobile Ad Hoc Networking and Computing (MobiHoc), Los Angeles, CA, June 2018 (AR: 16%).

219. B. Herrera, E. Demirors, G. Chen, R. Guida, F. Pop, N. Dave, C. Casella, T. Melodia, M. Rinaldi, "PMUT-Based High Data Rate Ultrasonic Wireless Communication Link for Intra-Body Networks," in Proc. of Hilton Head Workshop 2018, Hilton Head, SC, June 2018.

220. J. Jagannath, T. Melodia, "VL-MAC: An Opportunistic Medium Access Control Protocol for Visible Light Ad hoc Networks," in Proc. of IEEE International Conference on Computing, Networking and Communications (ICNC), Maui, Hawaii, March 2018.

221. F. Restuccia, E. Demirors, T. Melodia, "iSonar: Soware-Defined Underwater Networking for Amphibious Smartphones," in Proc. of ACM Conf. on Underwater Networks and Systems (WUWNet), Halifax, Canada, November 2017.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000199

222. L. Zhang, F. Restuccia, T. Melodia, S. Pudlewski, "Learning to Detect and Mitigate Cross-layer Attacks in Wireless Networks: Framework and Applications," in Proc. of IEEE Conf. on Communications and Network Security (CNS), Las Vegas, NV, USA, October 2017.

223. S. Colonnese, F. Cuomo, L. Ferranti, R. Guida, M. Pullo, T. Melodia, "UAV deployment in Heterogeneous Networks: Enhancing Video Streaming QoE," Proc. of Intl. Balkan Conference on Communications and Networking, Tirana, Albania, May-June, 2017.

224. G. E. Santagati, T. Melodia, "An Implantable Low-Power Ultrasonic Platform for the Internet of Medical Things," in Proc. of *IEEE Conference on Computer Communications (INFOCOM)*, Atlanta, GA, May 2017 (AR: 20%).

225. E. Demirors, J. Shi, R. Guida, T. Melodia, "SEANet G2: Toward a High-Data-Rate Software-Defined Underwater Acoustic Networking Platform," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Shanghai, China, October 2016.

226. E. Demirors, T. Melodia, "Chirp-Based LPD/LPI Underwater Acoustic Communications with Code-Time-Frequency Multidimensional Spreading," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Shanghai, China, October 2016. **BEST STUDENT PAPER AWARD**

227. R. Guida, G. E. Santagati, and T. Melodia, "A 700 kHz Ultrasonic link for wireless powering of implantable medical devices," in Proc. of IEEE Sensors, Orlando, Fl, USA, Oct-Nov 2016. **Invited Talk**

228. J. Jagannath, T. Melodia, A. Drozd, "DRS: Distributed Deadline-Based Joint Routing and Spectrum Allocation for Tactical Ad-hoc Networks," in Proc. of IEEE Global Communications Conference (GLOBECOM), Washington D.C., USA, December 2016.

229. J. Jagannath, H. Saarinen, T. Woods, J. O'Brien, S. Furman, A. Drozd, T. Melodia, "COmBAT: Cross-layer Based Testbed with Analysis Tool Implemented Using Software Defined Radios," in Proc. of IEEE Conf. on Military Communications (MILCOM), Baltimore, MD, USA, November 2016.

230. E. Demirors, G. Alba, G. E. Santagati, T. Melodia, "High Data Rate Ultrasonic Communications for Wireless Intra-Body Networks ," in Proc. of IEEE Symposium on Local and Metropolitan Area Networks (LANMAN), Rome, Italy, June 2016.

231. Z. Guan, T. Melodia, "CU-LTE: Spectrally-Efficient and Fair Coexistence Between LTE and Wi-Fi in Unlicensed Bands," in Proc. of IEEE Conference on Computer Communications (INFOCOM), San Francisco, CA, USA, April 2016 (AR: 18%).

232. E. Demirors, B. Shankar, G. E. Santagati, T. Melodia, "SEANet: A Software-Defined Acoustic Networking Framework for Reconfigurable Underwater Networking," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Washington D.C., USA, October 2015. **BEST STUDENT PAPER AWARD**.

233. L. Zhang, T. Melodia, "Hammer and Anvil: The Threat of a Cross-Layer Jamming-aided Data Control Attack in Multihop Wireless Networks," in Proc. of IEEE Conf. on Communications and Network Security (CNS), Florence, Italy, September 2015.

234. G. Sklivanitis, E. Demirors, A. Gannon, S. N. Batalama, D. A. Pados, T. Melodia "All-spectrum Cognitive Channelization around Narrowband and Wideband Primary Stations," in Proc. of of IEEE Global Communications Conference (GLOBECOM), San Diego, CA, USA, December 2015.

235. E. Demirors, G. Sklivanitis, T. Melodia, S. Batalama, "RcUBe: Real-Time Reconfigurable Radio Framework with Self-Optimization Capabilities," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Seattle, WA, June 2015 (AR: 25%).

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000200

236. N. Cen, Z. Guan, T. Melodia, "Multiview Video Streaming Based on Compressed Sensing: Architecture Design and Network Optimization," in Proc. of ACM Intl. Symp. on Mobile Ad Hoc Networking and Computing (MobiHoc), Hangzhou, China, June 2015 (AR: 14%).

237. I. Rubin, S. Colonnese, F. Cuomo, F. Calanca, T. Melodia, "Mobile HTTP-based streaming using flexible LTE base station control," in Proc. of IEEE Intl. Symp. on a World of Wireless Mobile and Multimedia Networks (WoWMoM), Boston, MA, June 2015.

238. G. E. Santagati, T. Melodia, "U-Wear: software-defined ultrasonic networking for wearable devices," in Proc. of ACM Intl. Conf on Mobile Systems, Applications, and Services (MobiSys), Firenze, Italy, May 2015 (AR: 13%).

239. Z. Guan, G. E. Santagati, T. Melodia, "Ultrasonic Intra-body Networking: Interference Modeling, Stochastic Channel Access and Rate Control," in Proc. of IEEE Conference on Computer Communications (INFOCOM), Hong Kong S.A.R., PRC, April 2015 (AR: 19%).

240. E. Demirors, G. Sklivanitis, G. E. Santagati, T. Melodia, S. N. Batalama, "Design of A Software-defined Underwater Acoustic Modem with Real-time Physical Layer Adaptation Capabilities," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Rome, Italy, November 2014.

241. H. Kulhandjian and T. Melodia, "Modeling Underwater Acoustic Channels in Short-range Shallow Water Environments," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Rome, Italy, November 2014.

242. J. Shi, Z. Guan, C. Qiao, T. Melodia, D. Koutsonikolas, and G. Challen, "Crowdsourcing Access Network Spectrum Allocation Using Smartphones," in Proc. of ACM Workshop on Hot Topics in Networks (HotNets), Los Angeles, CA, USA, Oct. 2014.

243. G. E. Santagati, M. Gradillo, F. Cuomo, T. Melodia, "A Comparison of MAC Protocols for Ultrasonic Intra-body Sensor Networks," in Proc. of Intl. Conf. on Body Area Networks (BodyNets), London, UK, September 2014.

244. G. Sklivanitis, E. Demirors, S. N. Batalama, T. Melodia, D. A. Pados, "Receiver Configuration and Testbed Development for Underwater Cognitive Channelization," Asilomar Conference on Signals, Systems and Computers, (ASILOMAR), November 2014.

245. H. Kulhandjian and T. Melodia "A Low-cost Distributed Networked Localization and Time-synchronization Framework for Underwater Acoustic Testbeds," in Proc. of IEEE Underwater Communications Conf. and Workshop (UComms), Sestri Levante, Italy, September 2014.

246. G. Sklivanitis, E. Demirors, S. N. Batalama, D. A. Pados, T. Melodia, "An All-GNU Radio Transceiver for All-Spectrum Cognitive Channelization," in GNU Radio Conference (GRCon14), Washington, DC (USA), September 2014.

247. H. Kulhandjian, T. Melodia, D. Koutsonikolas, "Securing Underwater Acoustic Communications through Analog Network Coding," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Singapore, June 2014.

248. G. E. Santagati, T. Melodia, "Sonar Inside Your Body: Prototyping Ultrasonic Intra-body Sensor Networks," in Proc. of *IEEE Conference on Computer Communications (INFOCOM)*, Toronto, Canada, April 2014 (AR: 19%).

249. L. Zhang, Z. Guan, T. Melodia, "Cooperative Anti-jamming for Infrastructure-less Wireless Networks with Stochastic Relaying," in Proc. of *IEEE Conference on Computer Communications (INFOCOM)*, Toronto, Canada, April 2014 (AR: 19%).

250. Nan Cen, Z. Guan, T. Melodia, "Joint Decoding of Independently Encoded Compressive Multiview Video Streams," in IEEE Picture Coding Symposium (PCS), San Jose, CA, December 2013.

251. Y. Sun, T. Melodia, "The Internet Underwater: An IP-compatible Protocol Stack for Commercial Undersea Modems," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Kaohsiung, Taiwan, November 2013. **BEST STUDENT PAPER AWARD**

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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Page 000201

252. J. Jagannath, A. Saji, H. Kulhandjian, Y. Sun, E. Demirors, T. Melodia, "A Hybrid MAC Protocol with Channel-dependent Optimized Scheduling for Clustered Underwater Acoustic Sensor Networks," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Kaohsiung, Taiwan, November 2013.

253. G. E. Santagati, T. Melodia, "Opto-Ultrasonic Communications in Wireless Body Area Nanonetworks," in Proc. of IEEE Asilomar Conf. on Signals, Systems, and Computers, Pacific Grove, CA, November 2013.

254. E. Natalizio, R. Surace, V. Loscri', F. Guerriero, T. Melodia, "Two Families of Algorithms to Film Sport Events with Flying Robots," in Proc. of IEEE Intl. Conf. on Mobile Ad-hoc and Sensor Systems (MASS), Hangzhou, China, October 2013.

255. L. Ding, Y. Sagduyu, T. Melodia, J. Li, J. Feldman, J. Matyjas, "CREATE-NEST: Meeting Deadlines in Distributed Cognitive Networks with Physical Channel Awareness," in Proc. of IEEE Conf. on Military Communications (MILCOM), San Diego, CA, USA, November 2013.

256. S. Colonnese, F. Cuomo, R. Guida, T. Melodia, "Cloud-assisted Buffer Management for HTTP-based Mobile Video Streaming," in Proc. of ACM Intl. Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN), Barcelona, Spain, November 2013.

257. G. Santagati, T. Melodia, L. Galluccio, S. Palazzo "Distributed MAC and Rate Adaptation for Ultrasonically Networked Implantable Sensors," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), New Orleans, LA, USA, June 2013 (AR: 18%).

258. Z. Guan, T. Melodia, G. Scutari "Distributed Queuing Games in Interference-limited Wireless Networks," in Proc. of IEEE Intl. Conf. on Communications (ICC) 2013, Budapest, Hungary, June 2013.

259. S. Pudlewski, T. Melodia, "RA-CVS: Cooperating at Low Power to Stream Compressively Sampled Videos," in Proc. of IEEE Intl. Conf. on Communications (ICC) 2013, Budapest, Hungary, June 2013.

260. H. Kulhandjian, T. Melodia, D. Koutsonikolas "CDMA-based Analog Network Coding through Interference Cancellation for Underwater Acoustic Sensor Networks," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Los Angeles, CA, USA, November 2012.

261. Z. Guan, T. Melodia, D. Yuan "Stochastic Channel Access for Underwater Acoustic Networks with Spatial and Temporal Interference Uncertainty," in Proc. of ACM Conference on Underwater Networks and Systems (WUWNet), Los Angeles, CA, USA, November 2012.

262. S. Colonnese, F. Cuomo, T. Melodia, "Leveraging Multiview Video Coding in Clustered Multimedia Sensor networks," in Proc. of of IEEE Global Communications Conference (GLOBECOM), Anaheim, CA, USA, December 2012.

263. H. Kulhandjian, L. Kuo, T. Melodia, D. Pados, D. Green "Towards Experimental Evaluation of Software-Defined Underwater Networked Systems," in Proc. of IEEE UComms, Sestri Levante, Italy, September 2012.

264. E. Koski, S. Chen, S. Pudlewski, and T. Melodia, "Network Simulation for Advanced HF Communications Engineering," IET Intl. Conf. on Ionospheric Radio Systems and Techniques (IRST), May 2012, York, United Kingdom.

265. L. Ding, Y. E. Sagduyu, J. Yackoski, B. Azimi-Sadjadi, J. Li, R. Levy, and T. Melodia, "High Fidelity Wireless Network Evaluation for Heterogeneous Cognitive Radio Networks," Proc. SPIE Defense, Security and Sensing Conference, Baltimore, MD, April 2012.

266. L. C. Kuo, T. Melodia, "Cross-layer Routing on MIMO-OFDM Underwater Acoustic Links," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Seoul, South Korea, June 2012 (AR: 19%).

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000202

267. K. Gao O. Ozdemir, S. Batalama, D. Pados, T. Melodia, A. Drozd, "Joint Admission Control and Resource Allocation in Cognitive Code-Division Networks," in Proc. of IEEE Intl. Work. on Signal Processing Advances in Wireless Communications (SPAWC), Cesme, Turkey, June 2012.

268. L. Galluccio, T. Melodia, S. Palazzo, G. E. Santagati "Challenges and Implications of Using Ultrasonic Communications in Intra-body Area Networks," in Proc. of IEEE Wireless On-demand Network Systems and Services (WONS), 2012, Courmayeur, Italy, Jan. 2012.

269. K. Gao, L. Ding T. Melodia, S. Batalama, D. Pados, J. Matyjas, "Spread-spectrum Cognitive Networking: Distributed Channelization and Routing," in Proc. of IEEE MILCOM 2011, Baltimore, MD, November 2011. **Best Paper Award Runner-up for IEEE MILCOM 2011 Track 3**.

270. Z. Guan, T. Melodia, D. Yuan, D. Pados, "Distributed Spectrum Management and Relay Selection in Interference-Limited Cooperative Wireless Networks," in Proc. of ACM Intl. Conf. on Mobile Computing and Networking (MobiCom), Las Vegas, NV, USA, Sept. 2011 (AR: 14%).

271. S. Pudlewski, T. Melodia, "A Rate Energy Distortion Analysis for Compressed Sensing Enabled Wireless Video Streaming on Multimedia Sensors," in Proc. of of IEEE Global Communications Conference (GLOBECOM), Houston, TX, USA, December 2011.

272. Z. Guan, T. Melodia, D.Yuan, "Optimizing Cooperative Video Streaming in Wireless Networks," in Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Salt Like City, Utah, June 2011 (AR: 23%).

273. L. Kuo and T. Melodia, "Tier-Based Underwater Acoustic Routing for Applications with Reliability and Delay Constraints," in Proc. of IEEE Intl. Workshop on Wireless Mesh and Ad Hoc Networks (WiMAN), Maui, HI, July 2011.

274. S. Colonnese, F. Cuomo, O. Damiano, V. De Pascalis, T. Melodia, "On the Adoption of Multiview Video Coding in Wireless Multimedia Sensor Networks," in Wireless Advanced 2011, London, June 2011.

275. Z. Guan, L. Ding, T. Melodia, D. Yuan, "On the Effect of Cooperative Relaying on the Performance of Video Streaming Applications in Cognitive Radio Networks," in Proc. of IEEE Intl. Conf. on Communications (ICC), Kyoto, Japan, June 2011.

276. C. Taysi, A. Guvensan, T. Melodia, "TinyEARS: Spying on House Appliances with Audio Sensor Nodes," in Proc. of ACM Workshop On Embedded Sensing Systems For Energy-Efficiency In Buildings (BuildSys) 2010, Zurich, Switzerland - November 2010.

277. L. Ding, P. Nagaraju, T. Melodia, S. Batalama, D. Pados, J. Matyjas, "Software-defined joint routing and waveform selection in cognitive ad hoc networks," In Proc. of IEEE MILCOM 2010, October 2010.

278. M. Li, S. Batalama, D. Pados, T. Melodia, M. Medley, J. Matyjas, "Cognitive code-division channelization with blind primary-system identification," In Proc. of IEEE MILCOM 2010, October 2010.

279. P. Nagaraju, E. Koski, T. Melodia, "A software-defined radio ionospheric chirpsounder for HF propagation analysis," in Proc. of HF Nordic Conference, Faro, Sweden, August 2010.

280. L. Ding, T. Melodia, S. Batalama, J. Matyjas, "Distributed Routing, Relay Selection, and Spectrum Allocation in Cognitive and Cooperative Ad Hoc Networks," in *Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, Boston, MA, June 2010 (AR: 23%).

281. S. Pudlewski, T. Melodia, A. Prasanna "C-DMRC: Compressive-Distortion Minimizing Rate Control for Wireless Multimedia Sensor Networks," in *Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, Boston, MA, June 2010 (AR: 23%).

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000203

282. S. Pudlewski and T. Melodia, "On the Performance of Compressive Video Streaming for Wireless Multimedia Sensor Networks," In Proc. of IEEE Intl. Conf. on Communications (ICC), Cape Town, South Africa, May 2010.

283. S. Pudlewski, A. Prasanna, and T. Melodia, "Resilient Image Sensor Networks in Lossy Channels Using Compressed Sensing," in Proc. IEEE Intl. Workshop on Information Quality and Quality of Service for Pervasive Computing (IQ2S) 2010, Manheim, Germany, March, 2010.

284. L. Ding, T. Melodia, S. Batalama, M. Medley, "ROSA: Distributed Joint Routing and Dynamic Spectrum Allocation in Cognitive Radio Ad Hoc Networks," in *Proc. of ACM Intl. Conf. on Modeling, Analysis and Simulation of Wireless and Mobile Systems* (MSWiM), Tenerife, Canary Islands, Spain, October 2009 (AR: 23%).

285. L. Ding, S. Pudlewski, T. Melodia, S. Batalama, J. Matyjas, M. Medley, "Distributed Spectrum Sharing for Video Streaming in Cognitive Radio Ad Hoc Networks," in *Proc. of Intl. Workshop on Cross-layer Design in Wireless Mobile Ad Hoc Networks*, 2009, Niagara Falls, CA.

286. L. Kuo, T. Melodia, "Medium Access Control for Underwater Acoustic Sensor Networks with MIMO links," in *Proc. of ACM Intl. Conf. on Modeling, Analysis and Simulation of Wireless and Mobile Systems* (MSWiM), Tenerife, Canary Islands, Spain, October 2009 (AR: 23%).

287. S. Pudlewski and T. Melodia, "DMRC: Distortion-minimizing Rate Control for Wireless Multimedia Sensor Networks," in *Proc. of on IEEE Intl. Conf. on Mobile Ad-hoc and Sensor Systems* (MASS) 2009, Macau, China, October 2009 (AR: 24%).

288. T. Melodia and I. F. Akyildiz, "Cross-layer QoS Support for UWB Wireless Multimedia Sensor Networks," *Proc. IEEE Conference on Computer Communications (INFOCOM)*, Mini-Conference, Phoenix, Arizona, April 2008 (AR: 29%).

289. T. Melodia, "Cross Layer Quality of Service Provisioning in Wireless Multimedia Sensor Networks," in *Proc. of IEEE Upstate New York Workshop on Communications, Sensors, and Networking* 2007, Syracuse, NY, November 2007.

290. D. Pompili, T. Melodia, and I. F. Akyildiz , "Efficient Communication Protocols for Underwater Acoustic Sensor Networks," Poster Presentation, in *Proc. of GT-GTRI Underwater Sensor Networks Workshop*, Atlanta, GA, June 2007.

291. D. Pompili, T. Melodia, and I. F. Akyildiz, "A Distributed CDMA-based Medium Access Control for Underwater Acoustic Sensor Networks," *Proc. of Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net)*, Corfu, Greece, June 2007.

292. F. Cuomo, S. D. Luna, U. Monaco, and T. Melodia, "Routing in ZigBee: benefits from exploiting the IEEE 802.15.4 association tree," in *Proc. of IEEE Intl. Conf. on Communications (ICC)*, Glasgow, United Kingdom, June 2007.

293. T. Melodia, D. Pompili, and I. F. Akyildiz, "A Communication Architecture for Mobile Wireless Sensor and Actor Networks," in *Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, Reston, VA, September 2006 (AR: 25%).

294. E. Stuntebeck, D. Pompili, and T. Melodia, "Wireless Underground Sensor Networks Using Commodity Terrestrial Motes," in *Poster Presentation, Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, Reston, VA, September 2006.

295. I. F. Akyildiz, D. Pompili, and T. Melodia, "State of the Art in Protocol Research for Underwater Acoustic Sensor Networks," in *Proc. of ACM Intl. Workshop on UnderWater Networks (WUWNet)*, Los Angeles, CA, Sept. 2006.

296. D. Pompili, T. Melodia, and I. F. Akyildiz, "Deployment Analysis in Underwater Acoustic Wireless Sensor Networks," in *Proc. of ACM Intl. Workshop on UnderWater Networks (WUWNet)*, Los Angeles, CA, Sept. 2006.

297. D. Pompili, T. Melodia, and I. F. Akyildiz, "Routing Algorithms for Delay-insensitive and Delay-sensitive Applications in Underwater Sensor Networks," in *Proc. of ACM Intl. Conf. on Mobile Computing and Networking (MobiCom)*, Los Angeles, CA, Sept. 2006 (AR: 11%).

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
Case No. IPR2025-00137; U.S. Patent No. 11,540,272
Page 000204

298. D. Pompili, T. Melodia, and I. F. Akyildiz, "A Resilient Routing Algorithm for Long-term Applications in Underwater Sensor Networks," in *Proc. of the Mediterranean Ad Hoc Networking Workshop (MedHocNet)*, Lipari, Italy, June 2006.

299. U. Monaco, F. Cuomo, T. Melodia, F. Ricciato, M. Listanti, "Data Gathering in Wireless Sensor Networks: Insights into Energy-oriented Approaches," in *Networking Workshop 2006*, Courmayeur, Italy, January 2006.

300. T. Melodia, M. C. Vuran, and D. Pompili, "The State of the Art in Cross-layer Design for Wireless Sensor Networks," in *Proceedings of EuroNGI Workshops on Wireless and Mobility. Springer Lecture Notes in Computer Science 3883*, Como, Italy, July 2005.

301. D. Pompili and T. Melodia, "Three-Dimensional Routing in Underwater Acoustic Sensor Networks," in *Proceedings of ACM Intl. Workshop on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN)*, Montreal, Canada, October 2005.

302. M. Borghini, F. Cuomo, T. Melodia, U. Monaco, and F. Ricciato, "Optimal Data Delivery in Wireless Sensor Networks in the Energy and Latency Domains," in *Proc. of IEEE Intl. Wireless Internet Conf. (WICON)*, Budapest, Hungary, July 2005.

303. T. Melodia, D. Pompili, V. C. Gungor, and I. F. Akyildiz, "A Distributed Coordination Framework for Wireless Sensor and Actor Networks," in *Proc. of ACM Intl. Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc)*, Urbana-Champaign, IL, May 2005 (AR: 14%).

304. D. Pompili and T. Melodia, "An Architecture for Ocean Bottom UnderWater Acoustic Sensor Networks," in *Poster Presentation, Proc. of the Mediterranean Ad Hoc Networking Workshop (MedHocNet)*, Bodrum, Turkey, July 2004.

305. G. Di Bacco, T. Melodia, and F. Cuomo, "A MAC Protocol for Delay-Bounded Applications in Wireless Sensor Networks," in *Proc. of the Mediterranean Ad Hoc Networking Workshop (MedHocNet)*, Bodrum, Turkey, June 2004.

306. F. Cuomo, G. Di Bacco, and T. Melodia, "Optimized Scatternet Topologies for Personal Area Networking in Dynamic Environments," in *Proc. of IEEE Intl. Conf. on Communications (ICC)*, Paris, France, June 2004.

307. T. Melodia, D. Pompili, and I. F. Akyildiz, "Optimal Local Topology Knowledge for Energy Efficient Geographical Routing in Sensor Networks," in *Proc. of IEEE Conference on Computer Communications (INFOCOM)*, Hong Kong, March 2004 (AR: 18%).

308. T. Melodia and F. Cuomo, "Locally Optimal Scatternet Topologies for Bluetooth Ad Hoc Networks," in *Proc. of IFIP Working Conference on Wireless On-demand Network Systems (WONS)*, Madonna di Campiglio, Italy, January 2004.

309. F. Cuomo, G. Di Bacco, and T. Melodia, "SHAPER: a Self-Healing Algorithm Producing multi-hop bluetooth scattERnets," in *Proc. of IEEE Global Communications Conference (GLOBECOM)*, San Francisco, CA, December 2003.

310. A. Roveri, C. F. Chiasserini, M. Femminella, T. Melodia, G. Morabito, M. Rossi, and I. Tinnirello, "The RAMON Module: Architecture Framework and Performance Results," in *Proc. of Intl. Workshop on QoS in Multiservice IP Networks (QoS-IP)*, Milan, Italy, February 2003.

311. A. Baiocchi, F. Cuomo, T. Melodia, A. Todini, and F. Vacirca, "Reconfigurable Packet Scheduling for Radio Access Jointly Adaptive to Traffic and Channel," in *Proc. of Intl. Workshop on QoS in Multiservice IP Networks (QoS-IP)*, Milan, Italy, February 2003.

312. F. Cuomo and T. Melodia, "A General Methodology and Key Metrics for Scatternet Formation in Bluetooth," in *Proc. of IEEE Global Communications Conference (GLOBECOM)*, Taipei, Taiwan, November 2002.

Petitioners' Exhibit 1003
Nokia of America Corp., et al. v. KT Corporation, et al.
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Demos

313. E. Moro, M. Polese, I. Filippini, S. Basagni, A. Capone, T. Melodia, "IABEST: An Integrated Access and Backhaul 5G Testbed for Large-scale Experimentation," Proc. of ACM MobiCom Demos, Sidney, Australia, Oct 2022.
314. A. Lacava, P. Nero, P. Locatelli, F. Cuomo, T. Melodia, "Demo Abstract: BE-Mesh: Bluetooth Low Energy Mesh Networking," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Paris, France, Apr 2019.
315. Z. Guan, L. Bertizzolo, E. Demirors, T. Melodia, "Demo Abstract: WNOS: Software-defined Generation of Distributed Optimal Control Programs for Wireless Networks," in Proc. of IEEE International Conference on Computer Communications (INFOCOM), Honolulu, HI, Apr 2018.
316. E. Demirors, G. Sklivanitis, T. Melodia, and S. N. Batalama, "Real Time Video Streaming in Underwater Acoustic Networks," in Demo Session of ACM Intl. Conf. on Underwater Networks and Systems (WUWNet), Washington, DC, October 2015. BEST DEMO AWARD SECOND PRIZE.
317. E. Demirors, B. G. Shankar, G. E. Santagati, and T. Melodia, "SEANet: A Software-Defined Acoustic Networking Framework for Reconfigurable Underwater Networking," in Demo Session of ACM Intl. Conf. on Underwater Networks and Systems (WUWNet), Washington, DC, October 2015.
318. G. Sklivanitis, E. Demirors, S. N. Batalama, D. A. Pados, and T. Melodia, "Rapid prototyping of PHY/MAC-reconfigurable software-defined underwater acoustic modems with GNU Radio," in GNU Radio Conference (GRCon15) , Washington, DC (USA), August 2015.
319. G. Sklivanitis, E. Demirors, D. A. Pados, S. N. Batalama, T. Melodia, J. Matyjas, " Demonstration of All-spectrum Cognitive Channelization on GNU Radio and USRPN-210," NATO Symposium on "Cognitive Radio and Future Network " (IST-123), The Hauge, The Netherlands, May 2014.
320. L. Ding, Y. Sagduyu, T. Melodia, J. Li, "CREATE-NEST: A Cognitive Radio Network Emulator and Simulator Testbed" in *ACM Mobicom*, DEMO Session, Las Vegas, NV, September 2011.
321. P. Nagaraju, L. Ding, T. Melodia, S. Batalama, D. Pados, J. Matyjas, "Implementation of a Distributed Joint Routing and Dynamic Spectrum Allocation Algorithm on USRP2 radios," in *Proc. of IEEE Intl. Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, DEMO Session, Boston, MA, June 2010.

Book Chapters and Editorials

322. M. Polese, M. Dohler, F. Dressler, M. Erol-Kantarci, R. Jana, R. Knopp, T. Melodia, "Guest Editorial Open RAN: A New Paradigm for Open, Virtualized, Programmable, and Intelligent Cellular Networks," IEEE Journal of Selected Areas in Communications, 2024.
323. F. Restuccia, T. Melodia, J. Ashdown, "Spectrum Challenges in the Internet of Things: State of the Art and Next Steps," IoT for Defense and National Security, 353-375, 2023.
324. L. Bonati, S. Basagni, T. Melodia "Advances in experimental wireless platforms and systems," Guest Editorial, Computer Networks, 2022.
325. T. Melodia, A. Iera, "2019 End of Year Editorial," Computer Networks, 2020.
326. T. Melodia, A. Iera, "Receiving the Baton," Editorial, Computer Networks, 2019.
327. J. Jagannath, N. Polosky, A. Jagannath, F. Restuccia and T. Melodia, "Neural Networks for Signal Intelligence: Theory and Practice," Machine Learning for Future Wireless Communications, John Wiley and IEEE, November 2019.

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328. T. Melodia, D. Pompili, G. Pau, "Guest Editorial: Celebrating Prof. Mario Gerla's 75th Birthday," Elsevier Ad Hoc Networks, March 2019.

329. F. Restuccia, S. D'Oro, L. Zhang, T. Melodia, "The Role of Machine Learning and Radio Reconfigurability in the Quest for Wireless Security," Book Chapter in Springer's Proactive and Dynamic Network Defense, Eds. Cliff Wang, Zhuo Lu.

330. C. Westphal, T. Melodia, W. Zhu, C. Zimmerer, "Guest Editorial: Video Distribution Over Future Internet," IEEE Journal of Selected Areas in Communications, 2016.

331. D. Pompili, T. Melodia, C. Petrioli, L. Yang, "Guest Editorial" Special Issue on Advances in Underwater Acoustic Communications and Networking," in Ad Hoc Networks (Elsevier), 2015.

332. S. Pudlewski and T. Melodia, "Low-complexity Video Streaming for Wireless Multimedia Sensor Networks," in *The Art of Wireless Sensor Networks,* Eds. Habib M. Ammari, Springer, 2014.

333. F. Dressler, W. Wang, M. Cesana and T. Melodia, "Guest Editorial - ACM MobiCom 2012: Best Posters and Demos," ACM SIGMOBILE Mobile Computing and Communications Review, vol. 16 (4), pp. 32-33, October 2012.

334. T. Melodia, "ACM MobiCom 2012: Best Workshop Papers," ACM SIGMOBILE Mobile Computing and Communications Review, vol. 16 (5), January 2013.

335. T. Melodia, H. Khulandjian, L.-C. Kuo, and E. Demirors, "Advances in underwater acoustic networking," in *Mobile Ad Hoc Networking: Cutting Edge Directions*, S. Basagni, M. Conti, S. Giordano, and I. Stojmenovic, Eds. Hoboken, NJ: John Wiley & Sons, Inc., 2013.

336. T. Melodia, M. Reisslein, "Guest editorial: Special issue on multimedia ad hoc and sensor networks," in *Ad Hoc Networks (Elsevier)*, 2011.

337. J. Zheng, S. Mao, S. Midkiff, T. Melodia, "Guest editorial: Special issue on advances in ad hoc networks," in *Ad Hoc Networks (Elsevier)*, 2011.

338. T. Melodia and I. F. Akyildiz, "Research Challenges for Wireless Multimedia Sensor Networks," in *Distributed Video Sensor Networks,* Eds. Bir Bhanu, Chinya V. Ravishankar, Amit K. Roy-Chowdhury, Demetri Terzopoulos, Hamid Aghajan, Springer, June 2010.

339. D. Pompili and T. Melodia, "Research Challenges for Communication Protocols in Underwater Sensor Networks," in *Underwater Acoustic Sensor Networks* Yang Xiao Ed., Auerbach, USA, May 2010.

340. M. C. Vuran, D. Pompili, T. Melodia, "Future Trends in Wireless Sensor Networks," in *Wireless Sensor Networks: A Networking Perspective* J. Zheng and A. Jamalipour Eds, Wiley-IEEE Press, 2008.

341. T. Melodia and K. R. Chowdhury, "Wireless Multimedia Sensor Networks: Challenges and Solutions," in *invited book chapter in Broadband Mobile Multimedia: Techniques and Applications*, Y. Zhang, S. Mao, L. T. Yang, and T. M. Chen, Eds. Auerbach Publications, CRC Press, Taylor & Francis Group, 2008.

342. D. Pompili, M. C. Vuran, and T. Melodia, "Cross-layer Design in Wireless Sensor Networks," in *Sensor Network and Configuration: Fundamentals, Techniques, Platforms, and Experiments*, N.P. Mahalik, Ed. Germany: Springer-Verlag, 2006.

PATENTS GRANTED

1. K. Enhos, E. Demirors, T. Melodia, "Visible-Light Software-Defined Modem," US Patent 17/804,443, 2024.
2. T. Melodia, L. Bertizzolo, Z. Guan, S. D'Oro, "Software-Defined Drone Network Control System," US Patent, 2024.

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3. L. Bertizzolo, H. Cheng, T. Melodia, S. D'Oro, "Distributed Deep Reinforcement Learning Framework for Software-Defined Unmanned Aerial Vehicle Network Control," US Patent 17/846,197, 2024.
4. T. Melodia, S. D'Oro, L. Bonati, "Operating System for Software Defined Cellular Networks," US Patent 17/605,266, 2024.
5. T. Melodia, L. Bonati, S. D'Oro, F. Restuccia, "Private 5G Cellular Connectivity as a Service Through Full-Stack Wireless Steganography," US Patent 17/316,773, 2024.
6. S. D'Oro, T. Melodia, F. Restuccia, L. Bonati, "Methods for Multi-Access Edge Computing Network Slicing in 5G Networks," US Patent, 2024.
7. D. Uvaydov, R. Guida, F. Restuccia, T. Melodia "Embedded Networked Deep Learning for Implanted Medical Devices," US Patent 11,969,266.
8. S. D'Oro, F. Restuccia, T. Melodia, "Methods for the Enforcement of Network Slicing Policies in Virtualized Cellular Networks," US Patent 11,956,763.
9. T. Melodia, F. Restuccia, "Deep Learning-Based Polymorphic Platform," US Patent 11,949,544, 2024.
10. T. Melodia, S. D'Oro, M Polese, L Bonati, "Intelligence and Learning in O-RAN for 5G and 6G Cellular Networks," US Patent 17/456,361, 2024.
11. T. Melodia, Z. Guan, G. E. Santagati "Medium-access control schemes for ultrasonic communications in the body based on second order statistics," US Patent 11,832,915, 2023.
12. T. Melodia, F. Restuccia, S. D'Oro, "Neural Network for Adversarial Deep Learning in Wireless Systems," US Patent 11,832,103, 2023.
13. T. Melodia, G. Santagati, "Ultrasonic Multiplexing Network for Implantable Medical Devices," US Patent 11,831,569, 2023.
14. T. Melodia, G.E. Santagati, "Internet-linked Network for Medical Devices," US Patent 11,826,119, 2023.
15. T. Melodia, G.E. Santagati, L. Galluccio, S. Palazzo "Transmission and Medium Access Control Techniques for Ultrasonic Communications in the Human Body", US Patent 11,813,037, 2023.
16. J. Jimenez, T. Melodia, "The Internet of Medical Things Through Ultrasonic Networking Technology," US Patent 11,701,518, 2023.
17. F Restuccia, T Melodia, "Real-Time Cognitive Wireless Networking Through Deep Learning in Transmission and Reception Communication Paths," US Patent 11,610,111, 2022.
18. M. Polese, F. Restuccia, T. Melodia, "Coordination-Free mmWave Beam Management With Deep Waveform Learning," US Patent 11,588,539 2022.
19. S. D'Oro, T. Melodia, F. Restuccia, "Device and Method for Reliable Classification of Wireless Signals," US Patent 11,611,457, 2022.
20. T. Melodia, F. Restuccia, E. Demirors, "Underwater Ultrasonic Communication System and Method," US Patent 11,575,987.
21. T Melodia, R Guida, GE Santagati, "Reconfigurable Implantable Medical System For Ultrasonic Power Control And Telemetry," US Patent 11,369,267, 2022.
22. T. Melodia, G.E. Santagati, "Ultrasonic Multiplexing Network for Implantable Medical Devices," US Patent 11,239,963.
23. T. Melodia, Z. Guan, "Distributed wireless network operating system," US Patent 11,240,137.
24. T. Melodia, F. Restuccia, S. D'Oro, "Real-Time Channel-Resilient Optimization of Radio Fingerprinting," US Patent 11,184,783, November 2021.
25. T. Melodia, G.E. Santagati, "Ultrasonic Network for Wearable Devices," US Patent 10,271,728.

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Nokia of America Corp., et al. v. KT Corporation, et al.
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26. T. Melodia, G.E. Santagati, "Internet-linked Ultrasonic Network for Medical Devices," US Patent 10,849,503.
27. T. Melodia, G.E. Santagati, "Ultrasonic Network for Wearable Devices," US Patent 11,020,001.
28. T. Melodia, G.E. Santagati, "Ultrasonic Multiplexing Network for Implantable Medical Devices," US Patent 10,396,948.
29. T. Melodia, G.E. Santagati, "Ultrasonic Multiplexing Network for Implantable Medical Devices," US Patent 10,790,946.
30. T. Melodia, G.E. Santagati, "Software-Defined Implantable Ultrasonic Device for Use in the Internet of Medical Things," US Patent 11,115,475.
31. T. Melodia, Z. Guan, "Method for Sharing of Unlicensed Radio Frequency Bands by Cellular LTE and WiFi Networks," US Patent 9,924,372.
32. T. Melodia, E. Demirors, "Method and Apparatus for Wireless Communications," US Patent 11,374,658, 2022.
33. T. Melodia, E. Demirors, "Method and Apparatus for Wireless Communications," Japan Patent 6855571.
34. T. Melodia, Z. Guan, G. E. Santagati "Medium-access control schemes for ultrasonic communications in the body based on second order statistics," US Patent 10,506,927.
35. T. Melodia, G.E. Santagati, L. Galluccio, S. Palazzo "Transmission and Medium Access Control Techniques for Ultrasonic Communications in the Human Body", US Patent 10,898,076.

PATENT APPLICATIONS

1. Pedram Johari, Tommaso Melodia, Michele Polese, Leonardo Bonati, and Davide Villa, "Smart and Real-time Digital Twins for Open, Programmable and Virtualized Wireless Network Systems," US Provisional Patent Application 18/924,579.
2. Emrecan Demirors, Deniz Unal, Kerem Enhos, and Tommaso Melodia, "Communication System and Method," U.S. Provisional Patent Application 63/656,465, 2024.
3. P. Johari, A. Saeizadeh, T. Melodia, J. Jimenez, "SeizNet: The Apparatus for a Deep Learning Based Implantable System to Predict Seizures," U.S. Provisional Patent Application 63/571,560, 2024.
4. T. Melodia, J. Jimenez, E. Demirors, "System and Methods for Using Ultrasonic Waves for Wireless Powering and Communication of a Cardiac Assist Device," US Patent App. 17/763,090, 2022.
5. F. Restuccia, T. Melodia, "Device and method for embedded deep reinforcement learning in wireless internet of things devices," US Patent App. 17/753,670, 2022.
6. T. Melodia, E. Demirors, "Method And Apparatus For Wireless Communications," US Patent App. 17/804,905, 2022.
7. L. Bertizzolo, T. Melodia, "Method for Spectrum Sharing by Primary and Secondary Networks Based on Cognitive Beamforming," US Patent App. 17/431,752, 2022.
8. T. Melodia, J. Jimenez, E. Demirors, "Secured Intrabody Networks and Interfaces for the Internet of Things and Multiple Uses of Ultrasound Wideband," US Patent App. 17/428,338, 2022.
9. M. Polese, F. Restuccia, T. Melodia, "Coordination-Free mmWave Beam Management With Deep Waveform Learning," US Patent App. 18/093,602, 2022.
10. T Melodia, E Demirors, "Method And Apparatus For Wireless Communications, " US Patent App. 16/915,563, 2021.

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11. F. Restuccia, S. D'Oro, T. Melodia, "Mechanism for Real-Time Spectrum-Driven Embedded Wireless Networking Through Deep Learning in the RF Loop," US Provisional Patent Application.
12. T. Melodia, G.E. Santagati, R. Guida, "A Reconfigurable Implantable Medical System for Ultrasonic Power Control and Telemetry," US Patent Application, November 2017.
13. T. Melodia, G.E. Santagati, ""An Ultrasonic Internet of Medical Things Platform for Telemetry, Remote Control and Implant-to-Implant Communications"," US Patent Application, November 2017.
14. L. Bonati, S. D'Oro, T. Melodia, M. Polese, "Zero-Touch Deployment and Orchestration of Network Intelligence in Open RAN Systems," US Provisional Patent Application.
15. L. Baldesi, F. Restuccia, T. Melodia, "System for Frequency Sharing in Open Radio Access Networks Using Artificial Intelligence," US Patent App. 17/944,687.
16. S. D'Oro, T. Melodia, F. Restuccia, C. Robinson, D. Uvaydov, M. Zhang, "Methods for real-time wideband RF waveform and emission classification," Provisional Patent application.
17. L. Bonati, S. D'Oro, T. Melodia, M. Polese, "Energy-aware Network Intelligence Scaling in Open RAN," Provisional Patent application.
18. L. Bonati, P. Brach del Prever, T. Melodia, M. Polese, S. D'Oro, "Methods for detecting, evaluating and mitigating conflicts in Open RAN," Provisional Patent application.

CONSULTING

- Airanaculus LLC, 2021-2024. Consulted on spectrum sharing and radio access network slicing.
- NEC Research Laboratories of Europe, 2023. Served on advisory board on 6G research.
- Bionet Sonar, Inc. 2018-2024. Consulted on underwater communication/networks and connected medical implants.
- Sapienza University of Rome, 2023. Consulted on sensing with networks of drones.
- Intelligent Automation, Inc., 2018-2020. Consulted on cognitive radio networks.

RESEARCH SPONSORED BY INDUSTRY

- Qualcomm (2022-2024). Open RAN and Large Language Models for Testing Automation.
- Mavenir (2021-2024). Deep Reinforcement Learning for Radio Access Network Control.
- Dell Technologies (2022-2024). Deep Reinforcement Learning for Radio Access Network Slicing.
- Interdigital (2020-2024). Federated Learning for Mobile Devices.
- NVIDIA (2022-2024). 6G Programmable Research Platforms.
- MITRE. Large-scale emulation of cellular networks.
- Deutsche Telekom (2023-2024). Intelligence Orchestration in Radio Access Networks.
- ETRI (2023-2024). Intelligence Orchestration in Radio Access Networks.
- Technology Innovation Institute (2024-2025). Software-defined networking for Connected Drones.
- Amplitech (2024). Interoperability with Massive MIMO Radios.
- Viavi (2022-2024). AI-based Channel Emulation.
- Keysight (2021-2024). Spectrum Sharing.
- Fujitsu (2023). Institute Membership
- Red Hat (2022-2024). RAN automation and orchestration.
- Raytheon (2019-2024). AI for jamming detection and mitigation.

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- Virginia Diodes (2024). Terahertz Communications.
- Verizon (2024). Open Radio Access Network and Digital Twins.
- Intel (2022-2023). Secure Network Slicing.
- AT&T (2021-2023). Application-aware RAN control.
- Qylur (2023-2024). AI for drones.

EXPERT WITNESS

- Certain Cellular Base Station Communication Equipment, Components Thereof, and Products Containing Same, No. 337-TA-1388 (ITC). Retained by McKool Smith on behalf of Ericsson.
- Certain Cellular Base Station Communication Equipment, Components Thereof, and Products Containing Same, No. 337-TA-1397 (ITC). Retained by McKool Smith on behalf of Ericsson.

SPONSORED RESEARCH

PI stands for Principal Investigator. Overall, funding exceeds $100M.

- Created, between 2019-2022, brand new industry consortium for the Institute for the Wireless Internet of Things. Consortium includes: (i) strategic members (supporting at least $120k per year) Keysight, Dell, Interdigital, Qualcomm, Mavenir, NVIDIA, Mitre, ETRI, Deutsche Telekom, Amplitech, Technology Innovation Institute, Verizon; (ii) industry members ($70k per year Viavi, Red Hat, AT&T, Raytheon, Fujitsu, Virginia Diodes, Qylur) and a number of startups. Overall funding $1.552M.
- "Phase II: Open 6G: O-RAN Compliant Open-source Protocol Stacks for Softwarized Dynamic Networking at the Edge," Army Research Laboratory (ARL), PIs: T. Melodia, S. DOro, M. Polese, P. Johari, $8.5M, 2024-2027.
- "TENORAN: Automated and fine-grained energy-efficiency profiling of Open RAN systems via high-fidelity standardized testing scenarios," U.S. Department of Commerce - National Telecommunications and Information Administration (NTIA), PIs S. DOro, T. Melodia, P. Johari, M. Polese, $2M, 2023-2025.
- "DigiRAN: Interoperability, Security and Performance Testing of Open RAN through High-Fidelity Digital Twins," U.S. Department of Commerce - National Telecommunications and Information Administration (NTIA), PIs P. Johari, T. Melodia, S. DOro, M. Polese, L. Bonati, $2M, 2023-2025.
- "AutoRAN: Automated End-to-End Continuous Testing for Open and Disaggregated Cellular Systems," U.S. Department of Commerce - National Telecommunications and Information Administration (NTIA), PIs M. Polese, T. Melodia, P. Johari, S. DOro, , L. Bonati, $2M, 2023-2025.
- "Federated Open B5G Environment Enabling NextGen AI/ML and Security for IoT," DARPA throuhg a sub from Andro Computational Solutions, PIs S. DOro, T. Melodia, $450K, 2024-2026.
- "OpenDT: O-RAN Digital Twin to Automate O-RAN End-to-End AI/ML Development and Testing on Colosseum," O-RAN ALLIANCE Next Generation Research Group, PIs M. Polese, T. Melodia, S. DOro, , L. Bonati, $200K, 2024.
- "Intelligence orchestration in O-RAN systems," Electronics and Telecommunications Research Institute (ETRI), PIs T. Melodia, M. Polese, DOro, L. Bonati, $100K, 2023-2024.
- "Research on Connected Autonomous Vehicles," Technology Innovation Institute, PIs T. Melodia, S. DOro, F. Restuccia, S. Basagni, K. Chowdhury, $350K, 2023-2025.

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- "Intelligence Orchestration in O-RAN Systems," Deutsche Telekom, PIs T. Melodia, M. Polese, L. Bonati, $80K, 2023-2024.
- "Open6G: An Open RAN Hub to Jumpstart Next-Generation AI-Driven Connectivity in Massachusetts," Massachusetts Technology Collaborative (MTC), PIs T. Melodia, P. Johari, S. DOro, M. Polese, A. Gosain, $1.5M, 2023-2025.
- "Networked defense against distributed jamming attacks," Raytheon, PI T. Melodia, $35K, 2023.
- "NeTS: Medium: Resilient-by-Design Data-Driven NextG Open Radio Access Networks," National Science Foundation, PIs: F. Restuccia, T. Melodia, A. Oprea, $900K, 2023-2026.
- "PAWR Project Office Renewal," National Science Foundation, PIs: M. Silbey, T. Melodia, S. Basagni, K. Chowdhury, W. Wallace, $2.8M (Northeastern share $1.2M), 2023-2024.
- "PFI-RP: Smart Seizure Prediction System based on AI-enabled Implantable Sensor Networks," National Science Foundation, PIs: T. Melodia, J. Jimenez, P. Johari, J. S Neimat, D. Pham, $550K, 2022-2025.
- "5G Differentiated Security," Intel (subcontract from Naval Information Warfare Center Atlantic), PIs: T. Melodia, S. DOro, $485K, 2022-2023.
- "Zylinium supplement for Colloseum, Task Order 3," OUSD, PIs: S. DOro, T. Melodia, M. Polese, $351K, 2023-2024.
- "Open 6G: O-RAN compliant open source protocol stacks for softwarized dynamic networking at the edge," Office of the Undersecretary of Defense, $2,339,415, PI Melodia.
- "Spectrum Testing, Modeling, and Emulation of V2X Communication Networks in Colosseum," Department of Transportation, $2,726,453, PIs Melodia, Basagni, Gosain, Johari, Chowdhury, 2021-2023.
- "4S-5G: Self-Adaptive Spectrum Sharing Systems for 5G-and-Beyond Open RANs, Air Force Research Laboratory(AFRL), PIs: F. Restuccia, T. Melodia, Project total: $1.5M, 2022-2025.
- "Smart AI-enabled Future-proof Engine for Guarding against Unauthorized and Anomalous RF Radiation (SAFEGUARD)," IARPA, subcontract from Airanaculus, $2,900,000, PIs Chowdhury, Melodia, Restuccia.
- "Narrowband Jamming Mitigation Through AI Enabled Pilot Randomization," Raytheon, $35k 2022
- "AI/ML Analytics and Applied AI," Raytheon, PI T. Melodia, $45k 2021
- "FASTER: Full-StAck Software-Defined Ultrabroadband Terahertz Radio Testbed for Tactical WirEless Research Beyond 5G," $738,576, PIs Melodia, Jornet, Basagni, Koutsonikolas, Chowdhury, Restuccia.
- "MRI: Development of X-Mili: An Open, Programmable Platform to Conquer the 5G and 6G Wireless Spectrum," $3M, NSF, Pis Koutsonikolas, Melodia, Jornet, Chowdhury, Basagni.
- "AI Institute: Symbiotic Foundations for AI and Network Research," $1.8M, Northeastern PIs Chowdhury, Ioannidis, Melodia (part of a $20M award to Ohio State University, PI Prof. Ness Shroff).
- "SPiNN for Wireless IoT," DARPA, $1M, PIs Erdogmus, Chowdhury, Closas, Wang, Melodia, $1M, 2022.
- "Platforms for Advanced Wireless Research (PAWR): DOD SC2 Supplement, Task order 2," PAWR LLC, PIs: T. Melodia, S, Basagni, K. Chowdhury, A. Gosain, $948K, 2020-2024.
- "MsRI-EC: Modular, Open Hardware-Software Prototyping Platform for the mmWave and Sub-THz Wireless Research Community," PIs Melodia, Jornet, Gosain, $50k.
- "AI Jump Start," Massachusetts Technology Collaborative, PIs Silevitch, Melodia, Dy, Rappaport, Kaeli, $2.2M.

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- "SII Planning: NASCE: A National Spectrum Center to Conquer, Program, and Protect the Wireless Spectrum," $200k, National Science Foundation, PIs Melodia, Jornet, Chowdhury, Basagni, Gosain.
- "Extreme Scale RF Test with DARPA Colosseum," MITRE, PI T. Melodia, K. Chowdhury $203,318, 2021.
- "Learning-Based Spectrum Holes Detection project," Raytheon, PI T. Melodia, $50k 2021.
- "Deep Reinforcement Learning for Polymorphic IoT Platforms," Raytheon, $35k PI T. Melodia, 2021.
- "PAWR Platform ARA: Wireless Living Lab for Smart and Connected Rural Communities," $8,000,000, PI T. Melodia, National Science Foundation, 2021-2026.
- "PAWR Platform POWDER-RENEW: A Platform for Open Wireless Data-driven Experimental Research with Massive MIMO Capabilities," supplemental funding, $814,69, PI, National Science Foundation.
- "Collaborative Research: CCRI: New: RFDataFactory: Principled Dataset Generation, Sharing and Maintenance Tools for the Wireless Community, $1.44M, co-PI, National Science Foundation.
- "WNOS G2: A Learning-Based Wireless Network Operating System with Autonomous Distributed Network Control," PI Tommaso Melodia, Office of Naval Research, $1M (2020).
- "Yearly Fee for Strategic Membership of W-IoT Institute," Nvidia, PI T. Melodia, 2021, $120k.
- "Yearly Fee for Strategic Membership of W-IoT Institute," Mavenir, PI T. Melodia, 2021, $70k.
- "Yearly Fee for Strategic Membership of W-IoT Institute," Red Hat, PI T. Melodia, 2021, $70k.
- "Yearly Fee for Strategic Membership of W-IoT Institute," Keysight, PI T. Melodia, 2020, $120k.
- "Research on O-RAN," AT&T Research, $25k, 2021.
- "Yearly Fee for Strategic Membership of W-IoT Institute," Interdigital, PI T. Melodia, 2021, $120k.
- "Yearly Fee for Strategic Membership of W-IoT Institute," Interdigital, PI T. Melodia, 2020, $120k.
- "Research on Intergrated Access and Backhaul at mmWave," AT&T Research, $25k, 2019.
- "Research on mmWave channel modeling," Facebook Connectivity, $20k, 2019.
- "Yearly Fee for Membership of W-IoT Institute," Bahcesehir University, PI T. Melodia, 2019, $20K.
- "Army Collaborative Research on Colosseum and RFMLS," Army Research Laboratory, PIs T. Melodia, K. Chowdhury, 2019, $100K.
- "Army Counter UAS Research," Air Force Research Laboratory, PIs K. Chowdhury, T. Melodia, 2019, $288K.
- "CCRI:Grand:COLOSSEUM: Opening and Expanding the Worlds Largest Wireless Network Emulator," National Science Foundation, PI T. Melodia, S. Basagni, K. Chowdhury, A. Gosain, $6.6M, 2019-2024.
- "RTML: Large, Efficient and Adaptive Real-Time Learning for Next Generation Wireless Systems," National Science Foundation, S. Ioannidis, K. Chowdhury, T. Melodia, Y. Wang, J. Dy, 2019-2022, $1M.
- "SpecEES DISCOVER: Device Identification for Spectrum-optimization using COnVolutional nEural networKs," National Science Foundation, PI K. Chowdhury, T. Melodia, $750k.

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- "PAWR Platform AERPAW in Raleigh, NC", National Science Foundation, $12,694,403 , PI T. Melodia, 2019-2025.
- "Deep Reinforcement Learning for Polymorphic IoT Platforms," Raytheon, PI T. Melodia, 2019, $35k.
- "A Learning-Based Wireless Network Operating System with Autonomous Distributed Network Control," PI Tommaso Melodia, Office of Naval Research, $100k (2019).
- "DURIP: PROTECT: A Millimeter-wave Programmable Radio platfOrm and Tactical wirelEss Communication Testbed," Office of Naval Research, PIs Tommaso Melodia, Kaushik Chowdhury, Stefano Basagni, Jose Martinez-Lorenzo, $295k (2019).
- "Toward Secure-by-Design Polymorphic IoT Platforms" Office of Naval Research OTA, PI Tommaso Melodia, $150k (9/1/2018-9/28/2019).
- "Robust Decentralized Classification and Coordination Algorithms for Swarms of SUAS" Air Force Research Laboratory, PIs J. Martinez-Lorenzo, T. Melodia, K. Chowdhury, H. Singh, C. Amato, $1.5M (8/1/2018-2/28/2020).
- REU Supplement for "MRI: SEANet: Development of a Software-Defined Networking Testbed for the Internet of Underwater Things" (Award 1726512), PI T. Melodia $8k, 2018.
- "Deep Reinforcement Learning for Polymorphic IoT Platforms," Raytheon, PI T. Melodia, 2018, $50k.
- "SwarmControl: Toward Elastic, Programmable, Optimized Tactical Swarm Networking," Air Force Research Laboratory $1.03M, PI T. Melodia (7/1/2018-6/31/2021).
- "NeTS: Medium: Collaborative: Reliable Underwater Acoustic Video Transmission Towards Human-Robot Dynamic Interaction," $500k, PIs Melodia, Rinaldi.
- "Deep Learning Convolutional Neural Networks for Radio Identification," DARPA RF Machine Learning, $1.5M, PIs K. Chowdhury, T. Melodia, S. Ioannidis, J. Dy (6/1/2018-5/30/2020).
- "PAWR Platform COSMOS in New York City", National Science Foundation, $6.5M, PI T. Melodia, 2018-2024.
- "PAWR Platform POWDER-RENEW in Salt Lake City", National Science Foundation, $25,000,000.00, PI T. Melodia, 2018-2024.
- "Creating a Resilient Internet of Things (IoT)," Global Resilience Institute Seed Grant, $100k, PIs: Ryan Ellis, Tommaso Melodia, Rob Knake.
- "Workshop Proposal: Advancing Frontiers in Seafloor Science and Engineering Research," $50k, NSF, PIs H. Singh, T. Melodia.
- "Software-Defined Expeditionary Cyber Networking With Distributed Control," Office of Naval Research, 2017-2018 ˜$400,000 (PI: Melodia).
- "LANET: Visible-Light Infrastructure-less Wireless Networks for Expeditionary Cyber Missions," ˜$400,000 2017-2018 (PI Melodia).
- "Tier 1: A Campus-wide initiative to advance Internet of Things research at Northeastern," $150k, PI, planning grant from Northeastern's Provost office.
- "MRI: SEANet: Development of a Software-Defined Networking Testbed for the Internet of Underwater Things," $1.57M ($1.1M from NSF), National Science Foundation, PIs: T. Melodia, M. Rinaldi, S. Basagni. M. Stojanovic.
- "Proposal to Establish the Platforms for Advanced Wireless Research Program Office," $6.1M, National Science Foundation, with US Ignite (Northeastern share $2,532,356), PIs: T. Melodia, S. Basagni, K. Chowdhury, E. Yeh, G. Noubir.
- "SDIoBT: Software-Defined Internet of Battlefield Things With Distributed and Cognitive Autonomous Control," **PI**, $333,333, (100%), Army Research Laboratory, 2017.

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- "NeTS: Small: Beyond Separate-Then-Centralize: A Cellular Operating System to Optimize Software-Defined 5G Wireless Networks," **PI**, $350,000, (100%), National Science Foundation, 2016-2019.
- "NeTS: Small: Toward Wirelessly Rechargeable And Ultrasonically-networked Implantable Systems," **PI**, $300,000, (50%), National Science Foundation, 2016-2019 (co-PI: Prof. M. Rinaldi).
- "Secure and High-Throughput Wireless Networking in the Presence of Cross-layer Attacks," **PI**, $227,065, (100%), Air Force Research Laboratory, 2016-2017.
- "Development of a Prototype Software-defined Underwater Modem," **PI**, $48,640, (100%), Canadian Defense and Research Development Center, 2016.
- "Dynamic Cross-Layer Routing Using Cognitive Spectrum Allocation," **PI**, $100,000 (100%), AFOSR STTR Phase 2.5 with Andro Computational Solutions, 2016-2017.
- "Toward Connected Health for Implants through an Internet of Medical Things Platform," PI, $40,000 (100%), Massachusetts Technology Transfer Center, 2016.
- "Toward Software-defined Automated Generation of Distributed Optimal Control Programs for Wireless Ad Hoc Networks," PI, $300,000, (100%), Office of Naval Research, 2016-2019.
- "Tier 1: The Multi-Site Ultrasonic Wireless Pacemaker-Defibrillator," PI, $27,500, (50%), NEU, 2015-2016 (co-PI: Prof. Rinaldi).
- "I-CORPS: Networking Medical Implants Through Ultrasounds," PI, $50,000, (100%), National Science Foundation, 2015-2016.
- "Towards Real-Time Video Surveillance in the Internet of Underwater Things," PI, $300,000, (50%) National Science Foundation, 2014-2017.
- "Toward Maximal Spectral-Efficiency Networking, **co-PI**, $2,720,000, (25%), US Air Force Research Laboratory, 2014-2017 (PI: Prof. Dimitris Pados, co-PIs: Weifeng Su, Stella Batalama).
- "CAREER: Towards Ultrasonic Networking for Implantable Biomedical Devices," **PI**, $450k, (100%), National Science Foundation CAREER Program, 2013-2018.
- "Travel Support for IEEE SECON 2013," National Science Foundation, **PI**, $10K, (100%), 2013.
- "Dynamic Routing and Spread-spectrum Channelization for Cognitive Ad Hoc Networking," **PI**, (34%), $358K, AFOSR STTR Phase II with Andro Computational Solutions, 2012 (co-PIs: Profs. Dimitris Pados, Stella Batalama).
- "Travel Support for IEEE ICC 2013," National Science Foundation, **PI**, (100%), $15K, 2012.
- "Toward Distributed Decision Making in Cognitive Radio Ad-hoc Networks Based on Bilevel Equilibrium Programming," **co-PI**, $400k, (50%), National Science Foundation, 2012-2015 (PI: Prof. Gesualdo Scutari).
- "Dynamic Cross-Layer Design for Robust Cognitive Networking with Physical Channel and Delay Awareness," **PI**, $175k, (34%), Office of the Secretary of Defense SBIR Phase II with Intelligent Automation, Inc, 2012-2014 (co-PIs: Profs. Dimitris Pados, Stella Batalama).
- Equipment and Software Donations from Intel Embedded Curriculum Program, 2012.
- Equipment and Software Donations from Xilinx University Program, 2012.
- "Compressed-Sensing-Enabled Cooperative Video Streaming For Wireless Multimedia Sensor Networks", **PI**, $300K, (100%), US Navy Office of Naval Research, 2011-2014.
- "NeTS: Towards Ubiquitous Multimedia Sensing Through Compressive Video Streaming," **PI**, $450K, (50%), National Science Foundation, 2011-2014 (co-PI: Prof. Dimitris Pados).
- "Travel Support for IEEE Infocom 2012," National Science Foundation, **PI**, $20K, (100%), 2012.

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- "Development of a MIMO Underwater Networking Testbed," **PI**, $857K, National Science Foundation, ($257K cost shared by UB), (20%), 2011-2014 (co-PIs: Profs. Stella Batalama, Weifeng Su, Dimitris Pados, Joseph Atkinson).
- "Dynamic Cross-Layer Design For Robust Cognitive Networking With Physical Channel And Delay Awareness," **PI**, $22K, (34%), Office of the Secretary of Defense SBIR Phase I with Intelligent Automation, Inc (co-PIs: Profs. Dimitris Pados, Stella Batalama).
- "Cognitive Jointly Optimal Code-division Channelization and Routing over Cooperative Links," **co-PI**, $670K, (33%), Air Force Research Laboratory, 2010-2013 (PI: Prof. Dimitris Pados).
- "Networking on Underwater Acoustic MIMO Links," **PI**, $287K, (25%), National Science Foundation, 2010-2012 (co-PIs: Profs. Weifeng Su, Dimitris Pados, Stella Batalama).
- "Dynamic Routing and Spread-spectrum Channelization for Cognitive Ad Hoc Networking," **PI** $39K, (34%), AFOSR STTR Phase I with Andro Computational Solutions, 2011 (co-PIs: Profs. Dimitris Pados, Stella Batalama).
- "Network Simulation for HF Software-defined Systems," **PI**, $76K, (100%), Harris Corporation, 2011-2013.
- "Research on Advanced RFID Systems," **co-PI**, $30K, (50%), Cameron Corporation, 2011-2012 (PI: Prof. Dimitris Pados).
- "Cognitive Airborne Networking: Self-aware communications via sensing, adaptation, and cross-layer optimization," **co-PI**, $510K, (25%) US Air Force Research Laboratory (PI: Prof. Dimitris Pados, co-PIs: Profs. Weifeng Su, Stella Batalama).
- "A Proposal to support student travel to the ACM CoNext 2010 Conference," National Science Foundation, **PI**, $10K, (100%) 2010-2011.

HONORS & AWARDS

Fellow, National Academy of Inventors (NAI)	2024
Best Paper Award, IEEE Globecom	2024
Best Paper Award, IEEE/IFIP CNSM	2024
Fellow, International Artificial Intelligence Industry Alliance (AIIA)	2024
Best Short Paper Award, IEEE VNC	2024
Best Paper Award Runner Up, IEEE NG-OPERA Workshop	2024
ACM Distinguished Member	2023
Honorary Director for Communication Technologies, Hanscom Air Force Base	2023
Best Paper Award, IEEE INFOCOM	2022
Fellow, Asia-Pacific Artificial Intelligence Association (AAIA)	2021
Best Paper Award, IEEE WoWMoM	2019
Best Paper Award, ACM WINTECH	2019
IEEE Communications Society Distinguished Lecturer	2019-2020
Soren Buus Outstanding Research Award	2018
IEEE Fellow	2018
College of Engineering Faculty Fellow	2017-2018
College of Engineering Faculty Research Team Award	2017

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Best Student Paper Award at ACM WUWNet	2016
ICCCN Conference Outstanding Leadership Award	2016
Best Student Paper Award at ACM WUWNet	2015
Best Demo Award (second prize) ACM WUWNet	2015
IEEE Infocom Distinguished Member of Technical Committee	2015
Outstanding Alumnus in Comm. Engineering (1999-2012), Univ. of Rome La Sapienza	2014
Best Student Paper Award at ACM WUWNet	2013
Most Cited Article Award, Elsevier	2013
NSF CAREER Award	2013
Granted early tenure and promotion by SUNY Buffalo	2012
Best paper award runner-up 2011 IEEE MILCOM - Track 3	2011
Elsevier Computer Networks Editor of the Year Award	2010
AFRL Summer Faculty Research Program	2010
Elsevier *Top Cited Paper Award*	2010
ESI ISI Thomson Reuters *Fast Breaking paper in the field of Computers Science*	2009
IEEE SECON 2006 National Science Foundation Student Travel Grant	2006
Georgia Tech BWN-Lab Researcher of the Year Award for outstanding contributions and professional achievements	2004
Winner of a Fulbright Scholarship for a M.S. in the United States	2002

TECHNOLOGY TRANSFER AND ENTREPRENEURSHIP

- Founder and President of BioNet Sonar Inc. (2019), Northeastern spinoff operating in the area of Internet of Things in extreme environments, including intra-body/medical applications, wearables, and underwater networks. BioNet Sonar has received over $10M in funding from Google, National Science Foundation, National Institutes of Health, and DARPA.
- Founder and President of zTouch Inc (2023), spinoff developing technologies for AI-based control and analytics for beyond-5G open, programmable and virtualized wireless networks.
- Co-founder of AENDUO (2013, http://www.aenduo.com/), Italian startup operating in the area of wireless health and telemedicine. As of 2020, Prof. Melodia does not own any shares in AENDUO.

PROFESSIONAL ACTIVITIES AND SERVICE TO SCIENTIFIC COMMUNITY

Current Editorial Activities

Editor-In-Chief, Computer Networks (Elsevier), 2019-2024, 2021 Impact Factor 5.493 (raised from 3.03 in 2018)

Area Editor for Wireless Networking, IEEE Transactions on Wireless Communications, 2022-2024.

Lead Guest Editor for IEEE Journal of Selected Areas in Communications (JSAC) Special Issue on Open RAN (2023).

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Past Editorial Activities

Associate Editor, IEEE Transactions on Mobile Computing (2012-2019).

Associate Editor, IEEE Transactions on Biological, Molecular, and Multi-Scale Communications (2016-2019)

Associate Editor, Smart Health (Elsevier) (2016-2019)

Area Editor, Computer Networks (Elsevier) (2008-2019, Impact Factor 3.03).

Guest Editor, Ad Hoc Networks (Elsevier), A Special Issue to Honor the 75th Birthday of Prof. Mario Gerla, Guest Editors Tommaso Melodia, Dario Pompili, Giovanni Pau.

Associate Editor, IEEE Transactions on Wireless Communications (2013-2018, Impact Factor 4.951).

Associate Editor, IEEE Transactions on Multimedia (2013-2016, Impact Factor 2.536).

Guest Editor, IEEE Journal of Selected Areas in Communications (JSAC), Special Issue on Video Distribution over Future Internet, 2016.

Guest Editor, Ad Hoc Networks (Elsevier) and Physical Communications (Elsevier), Joint Special Issue on Advances in Underwater Communications and Networks, 2015.

Guest Editor, Ad Hoc Networks (Elsevier), Special Issue on Multimedia Ad Hoc and Sensor Networks, 2010.

Guest Editor, Ad Hoc Networks (Elsevier), Special Issue on Advances in Ad Hoc Networks, 2010.

Editor, IEEE Communications Surveys and Tutorials (2010-2013, Impact Factor 3.692).

Editor, Wiley European Transactions on Emerging Telecommunications Technologies (2011-2013, Impact Factor 1.049).

Editor, ACM/Springer Wireless Networks (2011-2013, Impact Factor 0.958).

Editor, KSII Transactions on Internet and Information Systems (2010-2011).

Associate Editor, Journal of Sensors (Hindawi) (2007-2010).

Leadership Positions

Member, AI-RAN Alliance Board, 2024-

Advisory Board, IEEE Comsoc Extended Reality and Immersive Communication Industry Community (XR&ICOM IC)

General Chair, IEEE ICCCN 2024

Technical Program Chair, IEEE DCOSS-IOT 2024

Member, OpenAirInterface Software Alliance Board, 2023-

Advisory Board Member, NEC Research Europe, 2023

Member of ATIS nextG Alliance Research Council, 2022-.

Co-founder and Organizer, 6G Symposium 2020-.

Scientific Advisory Board, A5G Networks, Inc.

Editorial Board Member, 6G World.

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Advisory Board Member, DAEMON project (European Union ICT-52 H2020 Research and Innovation Action) 2021-2023.

General Chair, ACM WUWNet 2022

General Chair, IEEE WoWMoM 2022

Steering Committee Member, ACM/IEEE IWQoS, 2021-present.

Finance and Sponsorship chair, ACM MobiCom 2021.

General Chair, ACM MobiHoc 2020.

TPC Chair, ACM/IEEE IWQoS 2020, Hangzhou, China.

General Chair, ACM WINTECH 2020.

Steering Committee Member, IEEE SECON, 2019-present

EMPOWER EU Steering Council, 2019-present

PAWR Steering Council, 2018-present

General Chair, IEEE SECON 2019.

General Chair, ACM/IEEE NanoCom 2019.

Technical Program Committee Chair, IEEE INFOCOM 2018.

General Chair, IEEE LANMAN 2018.

IEEE Computer Society Fellows Evaluation Committee, 2018.

Area TPC Chair, IEEE INFOCOM 2016-2022

Poster Chair, ACM MobiHoc 2016

Technical Program Chair, IEEE ICCCN 2016

Student Activities Chair, EUSIPCO 2016

Workshop Chair, IEEE /ACM CHASE 2016.

Steering Committee Member, IEEE Workshop on Cross-Layer Cyber Physical Systems Security, 2016-present

Technical Program Chair, IEEE IPCCC 2015

General Vice Chair, ACM Conf. on Nanoscale Computing and Communications (Nanocom), 2015.

General Chair, ACM Intl. Conf. on Underwater Networks and Systems (WUWNet), 2014.

Technical Program Chair, ACM WiNTECH 2014 (co-located with ACM MobiCom).

Technical Program Chair, Unconventional Intrabody Communications Track (UnIC) (BODYNETS 2014-2015)

Workshop Chair, IEEE Annual Computer Communications Workshop (CCW), 2013.

Technical Program Committee Vice Chair, IEEE Globecom 2013.

Technical Program Committee Vice Chair for Information Systems, IEEE INFOCOM 2013.

Technical Program Chair, IEEE/IFIP Wireless On-demand Network Systems and Services (WONS), 2013, 2017.

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Technical Program Chair, ACM Intl. Conference on Underwater Networks and Systems (WUWNet), 2012.

Poster Chair, IEEE/ACM IPSN 2014.

Travel Grant Chair, IEEE ICC 2013.

Travel Grant Chair, IEEE SECON 2013.

Workshop Chair, IEEE DCOSS 2013.

Publications Chair, IEEE BlackSeaCom 2013, 2014.

Workshop Chair, ACM MobiCom 2012.

Best Demo Award Committee, ACM MobiCom 2012.

Travel Grant Chair, IEEE ICNP 2012.

Symposium Chair, Wireless Networks, IEEE ICNC 2012, Maui, Hawaii, 2012.

Travel Grant Chair, IEEE INFOCOM 2012, Orlando, Fl.

Track Co-Chair (Ad Hoc and Sensor Networks), IEEE Vehicular Technology Conference VTC Fall 2011, San Francisco, CA, USA.

Technical Program Committee Co-chair, IEEE/IFIP Conference on New Technologies, Mobility, and Security (NTMS) 2011, Paris, France.

Technical Program Committee Co-chair, IEEE/IFIP Mediterranean Workshop on Ad Hoc Networks (Med-Hoc-Net) 2011, Favignana, Italy.

Track Chair, IFIP Wireless Days 2010, Venice, Italy.

Technical Program Symposium Co-Chair, IEEE ICC 2009 - Ad Hoc and Sensor Networking Symposium.

Technical Program Committee Co-Chair, First International Workshop on Embedded Systems for Energy Efficiency in Buildings (BuildSys 2009), co-located with ACM Sensys 2009, Berkeley, CA, November 2009.

Chair, First International Workshop on Autonomic Wireless Networking (AWN 2009).

Chair, First IEEE Workshop on Multimedia Communications and Services, Co-located with IEEE Globecom 2010.

Travel Grant Chair, ACM CoNext 2010

Tutorial Chair, IEEE/IFIP Mediterranean Workshop on Ad Hoc Networks (Med-Hoc-Net), 2012

Demo Chair, ACM MSWiM 2010

Demo Chair, ACM Wintech 2011

Workshop Chair: ICST ADHOCNETS 2010, The Second International Conference on Ad Hoc Networks.

Panels Chair: ICST ADHOCNETS 2009, The First International Conference on Ad Hoc Networks.

Publicity Chair, ACM Workshop on Underwater Networks (2010, 2011).

Publicity Chair, 4th Wireless Internet Conference (WICON 2008).

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Technical Program Committee Membership

ACM Intl. Symp. on Mobile Ad Hoc Networking and Computing (MobiHoc), 2009, 2015-2021

IEEE Conf. on Computer Communications (INFOCOM) 2010-2024

ACM Intl. Conf. on Mobile Computing and Networking (MobiCom) 2008, 2019-2022

IEEE Conf. on Sensor, Mesh and Ad Hoc Communications and Networks (SECON) 2009-2020

IEEE Intl. Conf. on Distributed Computing Systems (ICDCS) 2010-2011, 2014, 2016-2017

IEEE Conf. on Communications and Networks Security (CNS) 2013-2017, 2019

IEEE DCOSS 2016

IEEE/ACM Conference on Connected Health (CHASE), 2016, 2018.

IEEE Conference on E-Health Networking, Applications, and Service (HealthCom), 2015

IEEE Conf. on Dynamic Spectrum Access Networks (DySPAN), 2015, 2017, 2018, 2019.

IEEE Intl. Conf. on Network Protocols (ICNP) 2014

Symposium on Algorithms and Experiments for Sensor Systems, Wireless Networks and Distributed Robotics (ALGOSENSORS) 2014

ACM Conf. on Nanoscale Computing and Communication (NANOCOM) 2014, 2017, 2018

IEEE Workshop on LTE in Unlicensed Bands: Potentials and Challenges, 2015.

ACM Conf. on Underwater Networks (WUWNet), 2011-2015

European Conference on Networks and Communications (EuCNC) 2014

IEEE Intl. Conf. on Mobile Ad-hoc and Sensor Systems, (MASS) 2008-2012, 2014-2016, 2018-2019.

European Conf. on Wireless Sensor Networks (EWSN), 2012-2015

IEEE Symp. on a World of Wireless Mobile and Multimedia Networks (WoWMoM), 2013, 2016.

ACM Intl. Conf. on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM) 2009-2010

IEEE Globecom 2008-2013

IEEE International Conference on Communications (ICC) 2010-2013

IEEE Workshop on Cloud-Processing in Heterogeneous Mobile Communication Networks (co-located with ICC), 2014-2015

IEEE Vehicular Technology Conference 2008-Spring, 2009-Spring, 2009-Fall, 2013-Spring, 2014-Fall

IEEE Symp. on Personal, Indoor, and Mobile Radio Communications (PIMRC) 2009-2010, 2013

IEEE/IFIP Conf. on Wireless On-demand Networked Systems (WONS) 2013-2016

ACM Intl. Workshop on Embedded Systems for Energy Efficiency in Buildings (BuildSys) 2009-2011

IEEE Intl. Conf. on Mobile Ad-hoc and Sensor Networks (MSN) 2010

ICST Intl. Conf. on Ad Hoc Networks, (ADHOCNETS) 2009-2011

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ICST Intl. Conf. on Body Area Networks (BODYNETS) 2010-2014

IFIP Networking 2009, 2011

IEEE Intl. Symp. on Wireless Communication Systems (ISWCS) 2009

IEEE Conf. on Local Computer Networks (LCN), 2009-2010

IFIP Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net) 2009-2016

IFIP Conf. on New Technologies, Mobility and Security (NTMS), 2009, 2011

IEEE Intl. Workshop on Carrier-grade Mesh Networks (CARMEN) 2010

IEEE Intl. Workshop on Underwater Networks (WunderNET) 2010

IEEE International Workshop on Mobility in Wireless Sensor Networks (MobiSensor) 2010-2011

IEEE Workshop on Cognitive Wireless Networks and Systems - Cogwinets 2008-2009

IEEE/IFIP Wireless Days 2008, 2010

ACM WUWNet Poster and Demo Session 2008-2009

ACM Q2SWinet 2008-2010

IEEE Intl. Conf. on Wireless and Mobile Computing, Networking, and Communications (WiMob) 2008-2010

Intl. Workshop on Information Quality and Quality of Service for Pervasive Computing (IQ2S), 2009-2010, 2016

IEEE Intl. Workshop on Dynamic Spectrum Access and Cognitive Radio Networks, 2008, 2010

IEEE Intl. Conf. on Circuits and Systems for Communications 2008.

IFIP Intl. Conf. on Wireless Sensor and Actor Network (WSAN), 2008.

ACM Intl. Symp. on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (PE-WASUN) 2007-2013.

Reviewer Activity

Panelist, PAWR Panels, 4 between 2018-2020

Panelist, AFRL Expert Panel for Spectrum Warfare & Communications

National Science Foundation Panelist (21 times between 2008-2022)

National Institutes of Health Study Group Panelist (2017)

Panelist for Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR) (2010-2016)

NASA Panelist (2008, 2011)

Proposal Reviewer, IWT (research and innovation funding agency of the Flemish (Belgian) government), 2010

Proposal Reviewer, Luxembourg National Research Fund, 2010

Proposal Reviewer, University of Cyprus

Proposal Reviewer, U.S. - Israel Binational Science Foundation, 2009, 2011

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Proposal Reviewer, U.S. Army Research Office, 2009

Proposal Reviewer, Qatar National Research Foundation, 2009, 2010, 2011, 2014.

Proposal Reviewer, European Research Excellence program, 2009.

Reviewer for IEEE Journals: IEEE/ACM Transactions on Networking, IEEE Transactions on Mobile Computing, IEEE Transactions on Vehicular Technology, IEEE Transactions on Parallel and Distributed Systems, IEEE Transactions on Communications, IEEE Transactions on Wireless Communications, IEEE Communications Magazine, IEEE Communications Letters, IEEE Network, IEEE Journal of Oceanic Engineering, Proceedings of the IEEE, IEEE Transactions on Information Technology in BioMedicine, IEEE Transactions on Multimedia, IEEE Transactions on Circuits and Systems for Video Technology, IEEE Transactions on Signal Processing, IEEE Transactions on Broadcasting

Reviewer for Elsevier Journals: Computer Networks, Ad Hoc Networks, Pervasive and Mobile Computing, Ocean Engineering

Reviewer for ACM Journals: ACM Computer Communication Review, ACM Transactions on Sensor Networks

Reviewer for Hindawi Journals: EURASIP Journal on Wireless Communications and Networking

Reviewer for Wiley Journals: Wireless Communications and Mobile Computing, Journal of Communication Systems

Reviewer for Springer Journals: Wireless Networks

Regular Book Reviewer for Elsevier Science & Technology Books, Wiley Press, Springer, Cambridge University Press

RESEARCH GROUP

Research Scientists and Faculty

- Abhimanyu Gosain (PAWR Technical Program Director)
- Emrecan Demirors (Research Assistant Professor)
- Salvatore D'Oro (Research Assistant Professor)
- Michele Polese (Research Assistant Professor)
- Pedram Johari (Principle Research Scientist)
- Paolo Testolina (Research Scientist)
- Maxime Elkael (Research Scientist)
- Gabriele Gemmi (Research Scientist)
- Eric Anderson (Research Associate Professor)
- Rajeev Gangula (Research Assistant Professor)
- Sakthivel Velumani (Software Engineer)
- Ted Werth (Executive-in-Residence)

Current Ph.D. Students

- Deniz Unal (started September 2018)
- Hai Cheng (started September 2018)
- Neagin Neasamoni Santhi (started September 2019)

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- Anu Jagannath (started September 2019)
- Clifton Paul Robison (started 2020)
- Davide Villa (2020)
- Andrea Lacava (joint with Sapienza Univ. of Rome, 2020)
- Maria Tsampazi (2021)
- Matteo Bordin (2022)
- Ali Salizadeh (2022)
- Pietro Brach Del Prever (2023)
- Stefano Maxenti (2023)
- Ravis Shirkhani (2023)
- Christopher Wozny (2023)
- Ergest Beshaj (2024)

Undergraduate Students

- Vladislav Martin
- Mert Bozbeyoglu

ADMINISTRATIVE STAFF

- Reena Cash (Executive Assistant)
- Evgeniia Kagramanova (WIoT Associate Director of Administration and Finance)
- Noah Smith (Administrative Assistant)
- Kenneth Laurent (Administrative Assistant)
- Kuntheary Macdiarmid (Administrative Assistant)

ALUMNI

Ph.D. Students and Postdoc Alumni

- Amani Al-Shawabkah (2024, joined Bionet Sonar)
- Kerem Enhos (2023, joined Bionet Sonar)
- Daniel Uvaydov (2023, joined Qualcomm)
- Jiacheng Shi (2023)
- Leonardo Bonati (2022, joined Northeastern WIoT as a Research Scientist)
- Luca Baldesi (2022, joined UC Irvine as a Research Scientist)
- Lorenzo Bertizzolo (2021, joined Apple)
- Raffaele Guida (2020, joined Bionet Sonar)
- Ludovico Ferranti (2020, RaiWay, Rome, Italy)
- Francesco Restuccia (postdoc, joined Northeastern University as Assistant Professor)
- Nan Cen (2019, joined Department of Computer Science, Saint Louis University)
- Jithin Jagannath (2019, Director of ML Research, Andro Computational Solutions)
- Zhangyu Guan (joined University at Buffalo as Assistant Professor)
- Liyang Zhang Ph.D. Electrical Engineering Northeastern (Google)

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- Emrecan Demirors Ph.D. Electrical Engineering Northeastern (Started August 2011; Defense April 2017; joined Northeastern as Research Assistant Professor, Bionet Sonar as CTO)
- G. Enrico Santagati, Ph.D. Computer Engineering Northeastern (Started August 2012; Defended January 2017; joined Bose as a Senior Software Engineer)
- Hovannes Kulhandjian, Ph.D. Electrical Engineering SUNY Buffalo (Started January 2011; Defended August 2014; joined California State University as Assistant Professor)
- Scott Pudlewski, Ph.D. Electrical Engineering SUNY Buffalo (Started August 2008; Defended May 2012; joined MIT Lincoln Labs; now at Air Force Research Laboratory)
- Lei Ding, Ph.D. Electrical Engineering SUNY Buffalo (Started January 2008; Defended June 2012; Accenture Cybersecurity R&D Labs)
- Li-Chung Kuo, Ph.D. Electrical Engineering SUNY Buffalo (Started January 2008; Defended October 2012)

M.S. Students Graduated (Thesis)

- Joseph Turco 2023 (Employment: Bionet Sonar)
- Neil Dave 2019 (Employment: Bionet Sonar)
- Melissa Pullo 2017 (visiting student from Sapienza University of Rome)
- Giovanni Alba 2016 (visiting student from Politecnico di Milano, Italy)
- Mirko Gradillo 2014 (visiting student from Sapienza University of Rome)
- Meghna Vaydia 2013-2014 (Employment: First Niagara Bank, Buffalo, NY)
- Yifan Sun 2012-2013 (Employment: Ph.D. student at Northeastern University, Boston, MA)
- Anu Saji 2012-2013 (Employment: Andro Computational Solutions, Rome, NY)
- Jithin Jagannath 2012-2013 (Employment: Andro Computational Solutions, Rome, NY)
- Pradeep Nagaraju, 2010-2011 (Employment: Qualcomm Atheros, San Jose, CA)
- Arvind Prasanna, 2010-2011 (Employment: Netronome Systems, Pittsburgh, PA.)
- Si Chen 2011-2012 (Employment: Ph.D. student in Computer Science and Engineering at UB)

M.S. Students (Research Project)

- Bharatwaj Gowri Shankar 2017 (Employment: Philips Healthcare)
- Amruta Sardeshpande, M.S. 2011 (Employment: Shell Global Solutions, Houston, TX)
- Kunal Ghose, M.S. 2009 (Employment: Qualcomm, San Diego, CA)
- Gautham Jayaram, M.S. 2008 (Employment: Qualcomm, San Diego, CA)

Undergraduate Students

- Christopher Tjahjadi-Lopez (Summer 2014, supported by Louis Stokes Alliance for Minority Participation)
- Yangyong Zhang (2013-2014, volunteer)
- Adam Czerniejewski (2012-2013, UB Presidential Fellow)

High School Students

- Taylor Travis (Summer 2010, supported by Buffalo Engineering Awareness for Minorities)

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Visiting Students/Scholars

- Cleverson Nahum (Visiting Ph.D. Student from Federal University of Par, Brazil, 2023-2024)
- Niccolo' Longhi (Visiting Ph.D. Student from University of Bologna, Italy, 2023-2024)
- Rawlings Ntassah, (Visiting Ph.D. Student from University of Trento, Italy, 2024)
- Pierluigi Locatelli (Visiting Ph.D. Student from University of Rome La Sapienza, Italy, 2023)
- Tommaso Ricci (Visiting Ph.D. Student from University of Rome Tor Vergata, Italy, 2023)
- Matteo Pagin (Visiting Ph.D. Student from University of Padova, Italy, 2023)
- Raoul Raftopoulos (Visiting Ph.D. Student from University of Catania, Italy, 2023)
- Ivan Palam (Visiting Ph.D. Student from University of Rome, Tor Vergata, Italy, 2023)
- Pietro Spadaccino (Visiting Ph.D. Student from University of Rome La Sapienza, Italy, 2023)
- Alessio Scalingi (Visiting Ph.D. Student from IMDEA Networks, Spain, 2023)
- Luca Antonelli (Visiting M.S. Student from University of Pisa, Italy, 2022)
- Claudio Fiandrino (Visiting Postdoctoral Scholar from IMDEA Networks, Spain, 2022)
- Eugenio Moro (Visiting Ph.D. Student from Politecnico di Milano, Italy, 2022)
- Mattia Lecci (Visiting Ph.D. Student from University of Padova, Italy, 2021)
- Mohsen Hoshmand (Visiting Ph.D. Student from University of Padova, Italy), 2016.
- Simone Moretti (Visiting Ph.D. Student from University of Bologna, Italy), 2015.
- Davide Zordan (Visiting Ph.D. Student from University of Padova, Italy), 2013.
- Wu Peng (Visiting Ph.D. Student from Northwestern Polytechnical Unversity, China), 2013.
- Amac Guvensan. Visiting Ph.D. student from Yildiz Technical University, Turkey, January 2010 - June 2010. Employment: Assistant Professor at Yildiz Technical University, Turkey.
- Zhangyu Guan. Visiting Ph.D. student from Shandong University, P.R. China, September 2009 - September 2010. Employment: Postdoc at SUNY Buffalo.
- Donatella Ermini. Visiting Ph.D. student from University of Pisa, Italy, April 2010 - October 2010. Employment: Postdoc at University of Rome, La Sapienza, Italy.
- Z. Cihan Taysi. Visiting Ph.D. student from Yildiz Technical University, Turkey, January 2010 - June 2010. Employment: Postdoc at Yildiz Technical University, Turkey.
- Pietro Cassara. Visiting Ph.D. student from University of Palermo, Italy, May 2009 - November 2009. Employment: Researcher at National Research Council, Pisa, Italy.
- Giuseppe Enrico Santagati. Visiting M.S. from University of Catania, Italy, August 2011 - December 2011. Joined UB EE Ph.D. program in Fall 2012.
- Luigi Moriello. Visiting M.S. student from University of Rome La Sapienza, Italy, March 2008 - July 2008. Employment: Reply Consulting, Italy.
- Ilaria Di Bartolomeo. Visiting M.S. student from University of Rome La Sapienza, April 2009 - August 2009. Employment: Procter and Gamble, Italy.
- Enrico Corallo. Visiting M.S. student from University of Rome La Sapienza, April 2009 - August 2009. Employment: Deloitte Consulting, Italy.

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SCHOLARLY TALKS

Keynote Speeches and Plenary Talks

Keynote Speaker, IEEE WIOPT 2024, Seoul, South Korea

Keynote Speaker, IEEE World Forum on Internet of Things, October 2024

Keynote Speaker IEEE RFID 2024, June 2024

Keynote Speaker NTIA RAN Intelligent Controller Forum, March 2024

Distinguished Keynote Speaker, i2cat Center, February 2024

Keynote Speaker, 2023 IoT Forum, Sao Paulo, Brazil.

"Open6G: Toward Open, Programmable, and AI-Driven Wireless Systems," 2023 6G Symposium Keynote Speaker

"Open 6G: Toward A Reference Architecture For Programmable And AI-driven NextG Open RAN Systems" IEEE LANMAN 2023.

"Open 6G: Toward A Reference Architecture For Programmable And AI-driven NextG Open RAN Systems" KICS Summer Conference, South Korea, 2023.

"Open RAN: Architectures, Algorithms, Testbeds," IEEE Latincom 2022.

"Open RAN: Architectures, Algorithms, Testbeds," IEEE IPCCC 2022.

"Open RAN: Architectures, Algorithms, Testbeds," European Wireless 2022.

"Open RAN: Architectures, Algorithms, Testbeds," IEEE ICCCN 2022.

"Open RAN: Architectures, Algorithms, Testbeds," ACM ABS-6G Workshop 2022.

"Open RAN: Architectures, Algorithms, Testbeds," IEEE ICT 2021.

"Toward Fully Programmable, AI-Driven and Virtualized Wireless Networks for 5G and Beyond," IEEE DCOSS 2021.

"Toward Fully Programmable, AI-Driven and Virtualized Wireless Networks for 5G and Beyond," IEEE WoWMoM 2021.

"Toward Autonomous, Software-Defined Networks of Wireless Drones," IEEE DCOSS 2021.

"Toward Fully Programmable, AI-Driven and Virtualized Wireless Networks for 5G and Beyond," IEEE ICT 2021.

"Toward Autonomous, Software-Defined Networks of Wireless Drones," IEEE Robocom 2021.

"Toward Fully Programmable and Virtualized Wireless Networks for 5G and Beyond," ACM Intl. Workshop on Open Software Defined Wireless Networks (Openwireless), June 2020.

"Toward Autonomous, Software-Defined Networks of Wireless Drones," ACM Workshop on Micro Aerial Vehicle Networks, Systems, and Applications

"Toward Fully Programmable and Virtualized Wireless Networks for 5G and Beyond," Samsung Forum, May 2020.

"Platforms for Advanced Wireless Research at Scale," Keynote Talk at 5G Italy, Rome Italy, December 2019.

"When Deep Learning Meet Softwarization in 5G and IoT Systems," SAMSUNG AI Forum, Seoul,

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South Korea, November 2019.

"Secure-by-design Polymorphic IoT Platforms," Lipari Summer School, Italy, July 2019.

"Toward Fully Programmable Wireless Networks," Keynote Speech, IEEE Colcom 2019, Barranquilla, Colombia, June 2019.

"Toward a Unified Framework for Wireless Network Slicing," Invited Plenary Talk, Moscow Wireless Week, Institute for Information Transmission Problems (Kharlevic Institute), Russian Academy of Sciences, October 2018.

"Sonar inside your Body: Toward an Internet of Intra-Body Things," Keynote Speech, IEEE Internl. Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Bologna, Italy, September 2018.

"The Internet of Intra-Body Things," Keynote Speech, IEEE Intl. Conf. on Telecommunications and Signal Processing (TSP), Athens, Greece, July 2018.

"Toward a Fully Programmable Internet of Underwater Things," NSF Workshop on Seafloor Science and Engineering, Boston, MA June 2018.

"The Internet of Medical Things: Toward Implantable Ultrasonic Sensor Networks," Keynote Speech, ACM MobiSys 2018, Munich, Germany, June 2018.

"Toward Fully Programmable Wireless Networks," Keynote Speech, Balkancom 2018, Podgorica, Montenegro, June 2018.

"A Wireless Network Operating System," Keynote Speech, European Wireless 2018 Conference, Catania, Italy, May 2018.

"Toward an Internet of Underwater Things: A Roadmap," Invited Plenary Talk, ACM WUWNet, Shanghai, China, October 2016.

"Wireless Beyond RF: A Journey Through Standards and Systems," Invited Plenary Talk, GTTI Meeting, Genova, Italy, June 2016.

"Wireless Beyond RF," Invited Plenary Talk, New England Workshop on Software Defined Radios, Boston, MA, June 2016.

"Toward Ultrasonically Networked Miniaturized Medical Implants," Keynote Speech, IEEE 17th International Conference on e-Health Networking, Application and Services, Boston, MA, October 2015.

"Ultrasonic Networking" Keynote Speech, IFIP/IEEE 8th Wireless and Mobile Networking Conference (WMNC) Munich, Germany, October 2015.

"Sonar Inside Your Body: Toward Implantable Sensor Networks," Keynote Speech, IEEE Workshop on the Internet of Things: Smart Objects and Services (IoT-SoS) 2015 (co-located with IEEE WoWMoM 2015).

"Assured High-Throughput Wireless Networking Through Cooperation in the Presence of Heterogeneous Cross-layer Attacks," Keynote Speech, 7th IEEE Workshop on Cooperative and Cognitive Mobile Networks, London, UK June 2015 (co-located with IEEE ICC 2015).

"Compressive Wireless Video Streaming," Keynote Speech, European Wireless 2015 Conference, Budapest, Hungary May 2015.

"Ultrasonic Intra-body Networks," Invited Plenary Talk, TTI/Vanguard "Biotech and Beyond,", San Diego, CA, February 2015.

"How About an Internet of Intra-body Things?," Keynote Speech, IEEE Colombian Conference

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on Communications (COLCOM), Bogota', Colombia, June 2014.

Selected Invited Talks and Lectures

Research Triangle Invited Lecture Series, North Carolina State, Duke University, University of North Carolina at Chapel Hill, 2023

Invited Speaker, NSF Workshop on Spectrum Sharing, 2023

Invited Speaker om Future 6G Wireless Systems, US National Academy of Engineering - Sweden Royal Academy of Engineering Joint Meeting, Stockholm, Sweden.

Lecturer, IEEE Summer School on 6G Systems, 2023.

NEWSDR Workshop Invited Talk, 2023.

NSF MERIF Workshop, Invited Talk, May 2023.

ATIS Congressional Breakfast on 6G Funding, Panelist, April 2023.

Special Competitive Studies Project, Panel Meeting: Advanced Networks Technology and Policy, Washington DC, 2023.

Panelist on 6G Research Roadmap at 6G Summit

Distinguished Lecture at Technology Innovation Institute, 2022

Invited Seminar, Texas AM University, 2022

Invited Seminar, University of Bilbao, Spain, 2022

Invited Seminar, IMDEA, Spain, 2022

Invited Seminar, Universitat Politecnica de Catalunya, Spain, 2022

Invited Seminar, University of Washington, 2021

Talk at NSF Workshop on Next-G Security, Panel on "Security issues in the virtualization of Next-G networks," 2020

Panel at NSF Workshop on Spectrum: "We need a cultural shift to shape the wireless, ubiquitous, transparent, zero-power, and tactile Internet of the future," 2020.

Talk at FCC Advisory Group on Open Ran: "Toward Fully Programmable and Virtualized Wireless Networks for 5G and Beyond," 2020.

AI Panel at IEEE WOWMOM, "Toward Wireless Networks with a Brain?," 2020

"Toward Fully Programmable Wireless Networks for 5G and Beyond," Invited Seminar, 5G Italy, December 2019.

"Convolutional Neural Networks for RF Fingerprinting," Tutorial, IEEE MILCOM 2019.

"Understanding and Protecting the Wireless Spectrum," Invited Seminar, Raytheon, October 2019.

"Toward the Internet of Medical Things," Invited Seminar, University Mediterranea of Reggio Calabria, Italy, July 2019.

"Toward the Internet of Medical Things," Invited Seminar, University of Calabria, Italy, June 2019.

"Toward the Internet of Medical Things," Invited Talk, Bilkent University, Turkey, May 2019.

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"Body Area Networking: Sonar Inside Yoru Body," Invited Talk, Google Advanced Technology and Products (ATAP), February 2019.

"Toward Fully Programmable Wireless Networks," Sapienza University of Rome, July 2018.

"Toward an Optimization-Based Wireless Network Operating System," Invited Talk, IEEE ICNC 2018, Maui, Hawaii, 2018.

"Toward infrastructure-less software defined wireless networks," Invited Talk, GENI NICE 2017, Toronto, ON, Canada, October 2017.

"Towards 5G Networks," Invited talk at Nutaq Workshop on Massive MIMO, Quebec City, Canada, September 2017

"The Internet of Intra-Body Things: Toward Implantable Ultrasonic Sensor Networks," invited seminar at Shanghai Jiaotong University, China, October 2016.

"A 700 kHz Ultrasonic link for wireless powering of implantable medical devices," Invited Talk at IEEE Sensors 2016, Orlando, FL.

"Research Challenges in the Era of IoT," invited panel at IEEE ICCCN 2016, Big Island, Hawaii, August 2016.

"The Internet of Intra-Body Things: Toward Implantable Ultrasonic Sensor Networks," invited seminar at Universitat Politecnica de Catalunya, Barcelona, Spain, July 2016.

"How to Win an NSF CAREER Award (and learn a few things along the way)," Invited Talk at NSF CAREER Workshop, April 2016, George Washington University.

" Toward Implantable Intra-Body Networks of Biomedical Devices," Invited Seminar, Worcester Polytechnic Institute, March 2016.

"Toward An Internet of Intra-Body Things: Ultrasonic Sensor Networks of Miniaturized Medical Implants," Invited Seminar, University of Massachusetts Lowell, October 2015.

"Software-defined Networking for Ad Hoc Networks", Office of Naval Research, Washington D.C., June 2015.

"Cross-layer Adaptation in Underwater Networking," Invited Seminar, BAE Systems, Boston, June 2015.

"To Transmit or not to Transmit? Distributed Queuing Games in Infrastructure-less Wireless Networks", Naval Research Laboratory, Washington D.C., April 2015.

"Stochastic Medium Access Control for Ultrasonic Intra-body Networks," Invited Seminar, University of Massachusetts Dartmouth, February 2015.

"Cross-layer Adaptation in Underwater Networking," Invited Seminar, Ultra Maritime Digital Communications Centre, Dalhousie University, Halifax, Canada, Nov. 2014.

"Towards Implantable Ultrasonic Wireless Sensor Networks," Invited Seminar, Royal Institute of Technology (KTH), Stockholm, Sweden, September 2014.

"The Internet Underwater: Using Wireless Acoustic Networks To Monitor Undersea Conditions," Invited Talk, RFID Journal LIVE Conference and Exhibition, April 2014.

"Sonar Inside Your Body - Towards Implantable Ultrasonic Wireless Sensor Networks ," Invited Seminar, Northeastern University, Boston, February 2014.

"Sonar Inside Your Body - Towards Implantable Ultrasonic Wireless Sensor Networks ," Invited Seminar, University of California Los Angeles, January 2014.

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"Towards Ultrasonic Networking for Implantable Wireless Sensors," Invited Seminar, University of Padova, Italy, December 2013.

"Towards Ultrasonic Networking for Implantable Wireless Sensors," Invited Seminar, University of Rome La Sapienza, Italy, December 2013.

"Towards Ultrasonic Networking for Implantable Wireless Sensors," Invited Seminar, University of Rome Tor Vergata, Italy, November 2013.

"Towards Ultrasonic Networking for Implantable Wireless Sensors," Invited Seminar, Rice University, September 2013.

"How to Win an NSF CAREER Award (and learn a few things along the way)," Invited Talk at NSF CAREER Workshop, March 2013, Temple University, Philadelphia, PA.

"Ultrasonic Wide Band: MAC and Rate Adaptation for Ultrasonically Networked Implantable Sensors" Invited Talk at University of Michigan-Dearborn, February 2013.

"Compressed-sensing-based video streaming for wireless multimedia sensor networks," Invited Talk at Seoul National University, South Korea, June 2012.

"Underwater Sensor Networks," Invited Talk at the First International Conference on Wireless Technologies for Humanitarian Relief (ACWR), Kerala, India, December 18-21, 2011

"Towards Software-defined Underwater Networks - Trends and Opportunities for Underwater Networks and Systems," invited panel at ACM WUWNet 2011, Seattle, WA, December 2011.

"Cooperative Routing and Spread-Spectrum Channelization in Cognitive Ad Hoc Networks", invited talk at TTCP C3I TP6 Workshop on Tactical Communications, SPAWAR, San Diego, October 2010.

"Joint Routing and Spread-Spectrum Channelization for Cognitive Ad Hoc Networks," Cognitive RF Workshop, AFRL, Rome, NY, September 2010.

"Exploiting Cooperation in Cognitive Radio Networks," Air Force Research Laboratory, Rome, NY, July 2010.

"Experimental Research: Fashionable or Fundamental?" Invited Panel at IEEE SECON 2010, Boston, MA, June 2010.

"Joint Routing and Dynamic Spectrum Allocation in Cognitive Radio Ad Hoc Networks," invited Seminar, Toronto Networking Seminar Series, University of Toronto, February 26, 2010.

"The Role of Cross-layer Design in the Future Wireless Internet," Invited Panel, Intl. Workshop on Cross-layer Design (IWCLD), Palma de Mallorca (Spain), June 11-12, 2009.

"Routing and Medium Access Control Protocols in Underwater Acoustic Sensor Networks," Graduate Seminar Series, University at Buffalo, February 2009.

"Routing and Medium Access Control Protocols in Underwater Acoustic Sensor Networks," invited seminar, 18 December 2008, Dipartimento di Elettronica ed Informazione, Politecnico di Milano, Italy.

"Research Challenges for Next-Generation Wireless Sensor Networks," invited seminar, IEEE COMSOC Chapter, Rochester NY, February 2008.

"Future Research Trends in Wireless Sensor Networks," Plenary Talk, IEEE Colombian Conference on Communications (COLCOM), Bogota', Colombia, September 2007.

Invited Short Courses

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"Understanding Open RAN," 1st International School on Internet of Things Edge AI: Computing, Communications and Systems, September 2022.

"Understanding Open RAN," invited one week course at 2022 Lipari International School on "Network Analysis, Design and Optimization," July 2022.

"Advances in Wireless Network Optimization," invited one week course at 2014 Lipari International School on "Network Analysis, Design and Optimization," July 2014.

"A Tutorial on Underwater Communications and Networks," invited half-day tutorial at IEEE Colcom 2014, Bogota', Colombia, June 2014.

"Energy-efficient Wireless Multimedia Sensor Networks through Compressed-sensing Enabled Video Streaming," invited lecture at 2013 GreenComNet Summer School at Northeastern University, Boston, MA, May 2013.

"Cross-layer Design and Optimization in Multi-hop Wireless Networks," invited one week course for Ph.D. students at Politecnico di Milano, Italy, December 2008.

"A Tutorial on Wireless Multimedia Sensor Networks," invited short course, Escuela Politecnica del Ejercito, Quito, Ecuador, June 2008.

"Wireless Multimedia Sensor Networks," invited half-day tutorial at IEEE Colcom 2007, Bogota', Colombia, September 2007.

UNIVERSITY SERVICE (Northeastern)

ECE IT Support Search Committee, 2019.

ECE Hiring Committee, 2018-2023.

ECE Faculty Council, 2016-2019

College of Engineering Research Advancing Priorities Committees, 2015-

ECE Chair Search Committee, 2016-2017

ECE Undergraduate Curriculum Committee, 2016-2017

ECE General Faculty Search Committee, 2016.

Cyber Human Systems Engineering Faculty Search Committee, 2015-2016.

Computation, Systems, and Architectures Faculty Search Committee, 2014-2015.

ECE Merit Review Committee, 2014-2015.

UNIVERSITY SERVICE (SUNY Buffalo)

EE Faculty Search Committee Chair, 2014.

SEAS Undergraduate Programming Curriculum Committee, 2014.

University-wide General Education Reform Committee, 2014.

SEAS Faculty Honors and Awards Committee, 2013-2014.

SEAS Promotion and Tenure Committee, 2013-2014.

Director of International Exchange Programs for Electrical Engineering.

- Established new graduate/undergraduate student exchange program with University of Rome, La Sapienza (Italy) (2012).

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- Established new graduate/undergraduate student exchange program with Telecom Paris Sud (Paris, France) (2012), including a dual M.S. agreement.
- Assisted Department Chair in establishing new exchange program with Universidad Politecnica de Valencia (Spain) (2012).
- Revitalized exchange program with Chalmers University in Gothenburg, Sweden (2012);
- Coordinated EE exchange program with *"Ecole Nationale Superieure De L'Electricite"* (ENSEA), Cergy, France (2007-2012).
- Coordinated FIPSE exchange with Brazilian Universities (Universidade Federale do Rio Grande du Norte, Universidade Federale de Rio Grande do Sul, Universidade Federale de Santa Caterina) (2008-2011);
- Coordinated development of EE Study Abroad Website.

Member of the EE Faculty Search Committee, 2010, 2011, 2012, 2013.

Member of the EE Promotion and Marketing Committee, 2012-2014.

Member of the EE Awards Committee, 2007-2010.

COURSES TAUGHT

- EECE5698 Wireless Sensor Networks and The Internet of Things, (Spring 2016, Enrollment: 44, Spring 2019, Enrollment 55).
- EECE 2540 Fundamentals of Networks. (Fall 2015, Enrollment: 40; Spring 2017 (2 sections), Enrollment 90)
- EECE5698 Networks: Technology, Economics, Social Interactions, (Spring 2015, Enrollment: 48)
- Discovery Seminar: Wireless Health (1 credit hour course for honor undergraduate students) (Spring 2014, Enrollment: 12).
- Network Infrastructures, University of Rome La Sapienza (Fall 2013, 20 hours; taught one module on LTE-Advanced and one module on Software-defined Networks for 1st year graduate students, Enrollment: 80).
- EE450/550 Networks: Technology, Economics, Social Interactions, (Spring 2013, Enrollment: 36)
- EE605, Optimization for Wireless Networks, Fall 2009 (Enrollment: 25), Fall 2011 (Enrollment: 19), Fall 2012 (Enrollment: 26). Newly designed and developed graduate level course. Developed new material (Power Point slides, Homework Assignments, Final Projects).
- EE533, Wireless Multimedia Sensor Networks: Spring 2008 (Enrollment: 23), Fall 2008 (Enrollment: 24), Spring 2011 (Enrollment: 43), Spring 2012 (Enrollment: 43). Newly designed and developed graduate level course. Developed new material (Power Point slides, Homework Assignments, Final Projects).
- EE303, Signal Analysis and Transform Methods, Fall 2007 (Enrollment: 45), Fall 2010 (Enrollment 50). Developed new material (Power Point slides).
- EE585 Graduate Seminar Series, Fall 2008 (Enrollment: 77), Fall 2009 (Enrollment: 149), EE586 Graduate Seminar Series, Spring 2009 (Enrollment: 85), Spring 2010 (Enrollment: 149).
- Individual Problem with 5 students in Fall 2007, 3 students in Spring 2008, 1 student in Fall 2008, 2 students in Spring 2009, 3 students in Fall 2009, 1 student in Fall 2011.

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PROFESSIONAL MEMBERSHIP

Fellow, Institute of Electrical and Electronics Engineers (IEEE)

Distinguished Member, Association for Computing Machinery (ACM)

Fellow, National Academy of Inventors

Department of Defense Software Defined Radio (SDR) Working Group

Member, IEEE Communications Society

Member, IEEE Computer Society

Member, ACM Special Interest Group on Mobility of Systems, Users, Data, and Computing (SIGMOBILE)

Co-Chair, IEEE MMTC Special Interest Group on Distributed and Sensor Networks for Mobile Media Computing and Applications (2010-2012).

SELECTED PRESS COVERAGE

Underwater Internet:

"Internet takes to new depths underwater", CNN, Erin Burnett's Outfront, aired on 18 November 2013, URL: http://cnn.it/1hTsM0y

"Finally, the Underwater Wireless Modem We've All Been Waiting For," Wired, October 2013, URL: http://wrd.cm/19MLEnH

"Underwater Wi-Fi given test run to create 'deep-sea Internet'," BBC News, October 2013, URL: http://t.co/xOIjRoxmfZ

"Deep-sea Internet to detect tsunamis, spy on smugglers, and discover oil," NBC News, October 2013, URL: http://nbcnews.to/I10zVt

"Scientists Test 'Deep Sea Internet' To Standardise Underwater Communications," Huffington Post, October 2013, URL: http://bit.ly/1hYX423

"Underwater Internet to Make Ocean More Wi-Fi Friendly", ABC News, October 2013, URL: http://abcn.ws/1aw6Ovh

"Taking the Internet Underwater," UB News Center, October 2013, URL: http://bit.ly/19MW3ps

Ultrasonic Implantable Sensor Networks:

"Unexpected: A Sonar-Based Wireless Network that Lives in Your Body," Time Magazine Techland, June 2013, URL: http://ti.me/11EtEYG

"Not-so-alien Implants," The Economist (GE Lookahead), August 2013, URL: http://bit.ly/14mb8L6

"Sonar could connect sensors in your body," Discovery News, June 2013, URL: http://bit.ly/15ETQHD

"Sonar could let your body talk to machines better," Gizmodo, June 2013, URL: http://bit.ly/11ZNCDh

"The next frontier of wireless tech? Your body," UB News Center, June 2013, URL: http://bit.ly/1aNbcm9

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