

# Exhibit E

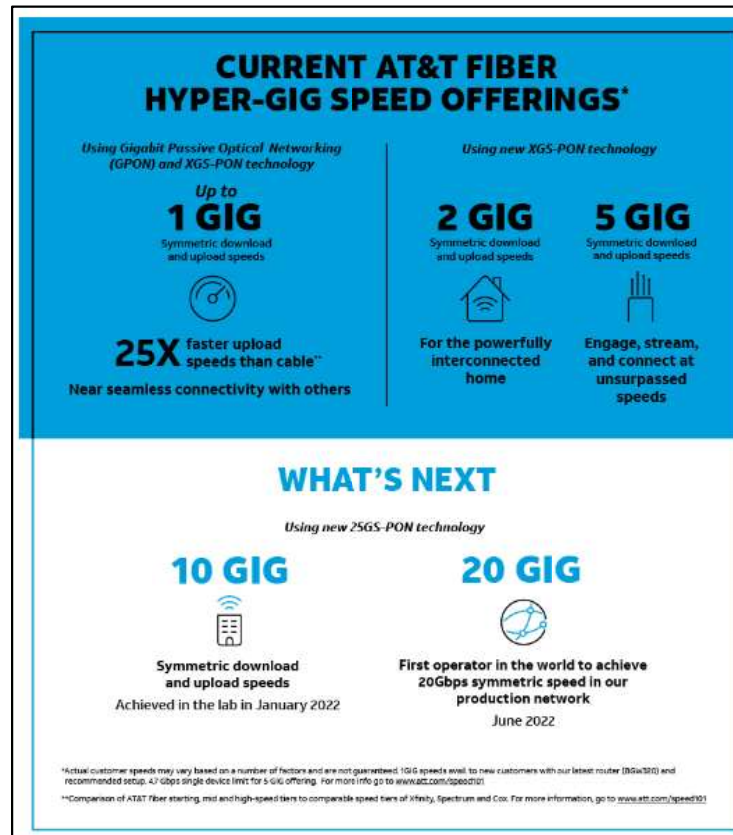
## Chart Detailing AT&T's Infringement of U.S. Patent No. 9,806,892

*Iarnach Techs. v. AT&T Corp., et al.*, Case No. 2:23-cv-0231-JRG (E.D. Tex.)

The Accused Instrumentalities include all components necessary for AT&T to provide fiber-optic networks and network services to its customers, including all hardware and software, optical line terminals (OLTs), and optical network units (ONUs)/optical network terminals (ONTs). This includes both residential and commercial customers, as well as fiber used in AT&T's wireless backhaul.

Based on the information presently available to it, Plaintiff Iarnach Technologies Limited ("Iarnach" or "Plaintiff") is informed and believes that AT&T directly and indirectly infringes U.S. Patent No. 9,806,892 (the "'892 Patent"). AT&T directly infringes claims 1, 2, 3, and 5 of the '892 Patent when it makes, uses, sells, and/or imports the Accused Instrumentalities. AT&T indirectly infringes claims 1, 2, 3, and 5 of the '892 Patent by actively inducing the direct infringement of its customers; AT&T actively induces its customers to use the Accused Instrumentalities.

| CLAIM 1                                                                                  | '892 PATENT V. AT&T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1[A].</b> A method of optical communication in a passive optical network, comprising: | <p>The Accused Instrumentalities implement a method of optical communication in a passive optical network.</p> <p>AT&amp;T began deploying fiber internet to homes and businesses in approximately 2010. <a href="https://about.att.com/innovationblog/2022/20-gbps-symmetric-speeds.html">https://about.att.com/innovationblog/2022/20-gbps-symmetric-speeds.html</a> (last visited April 24, 2023). AT&amp;T's original fiber-based networks implemented Gigabit Passive Optical Networking (GPON) technology. <i>Id.</i> In 2020, AT&amp;T began deploying an XGS-PON system. AT&amp;T describes itself as "an early adopter of XGS-PON with the largest deployment in North America." <i>Id.</i> AT&amp;T states that "with XGS-PON, we increased our network fiber capacity by 4x in the downstream and 8x in the upstream at roughly the same economics as our prior GPON investment." <i>Id.</i></p> |



*Id.* AT&T states that it is a member of the 25GSPON MSA group and expects “to bring 25GS-PON to maturity in the next 6 to 12 months.” *Id.*

AT&T’s new fiber services are based on XGS-PON. The following figure illustrates a typical XGS-PON Network.

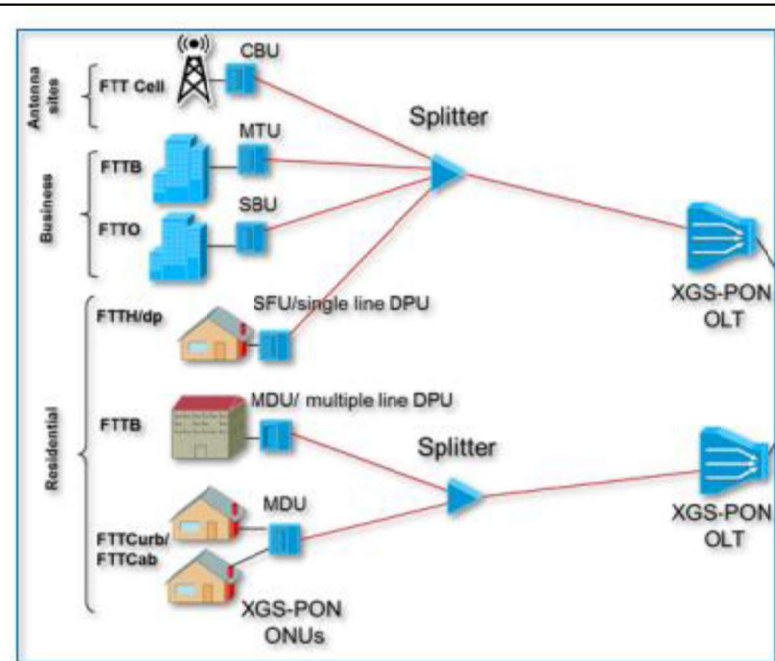


Figure 4 - XGS-PON Network

AT&T Open XGS-PON NFV 1RU OLT Specification at 9.

AT&T currently offers at least five fiber residential service plans: 5 GIG speed; 2 GIG speed; Up to 1 GIG speed; 500 Mbps speed; and 300 Mbps speed.

The screenshot displays three AT&T Fiber service plans under the heading "Special offer".

- Up to 1 GIG speed:**
  - Price: ~~\$80.00~~ **\$60.00/mo. plus taxes**
  - \*Price after discounts: \$20/mo w/elig wireless svc and \$5/mo Autopay & Paperless bill discounts (start w/in 2 bills). Monthly State Cost Recovery charge applies in OH, TX, NV. One time install fee may apply. [See offer details](#)
  - Check availability**
  - Features & benefits**
    - ✓ 25x faster upload speeds than cable<sup>3</sup>
    - ✓ Even faster online speeds for almost seamless connectivity, digital collaboration and pro-level gaming
- 2 GIG speed:**
  - Price: ~~\$150.00~~ **\$130.00/mo. plus taxes**
  - \*Price after discounts: \$20/mo w/elig wireless svc and \$5/mo Autopay & Paperless bill discounts (start w/in 2 bills). Monthly State Cost Recovery charge applies in OH, TX, NV. One time install fee may apply. [See offer details](#)
  - Check availability**
  - Features & benefits**
    - ✓ Ultra-fast online speeds to support smart-home activities, work-from-home demands, at-home learning and more
    - ✓ For the powerfully interconnected smart home
- 5 GIG speed:**
  - Price: ~~\$250.00~~ **\$230.00/mo. plus taxes**
  - \*Price after discounts: \$20/mo w/elig wireless svc and \$5/mo Autopay & Paperless bill discounts (start w/in 2 bills). Monthly State Cost Recovery charge applies in OH, TX, NV. One time install fee may apply. [See offer details](#)
  - Check availability**
  - Features & benefits**
    - ✓ Our fastest online speed to support cutting-edge technology such as elite gaming and truly immersive experiences
    - ✓ Engage, stream and connect at unsurpassed speed

<https://www.att.com/internet/fiber/> (last visited 9/8/2023).

AT&T currently offers at least six fiber commercial service plans: 5 GIG speed, 2 GIG speed, Up to 1 GIG speed, 500 Mbps speed, 300 Mbps speed, and 50 Mbps speed.

Get a \$500 reward card

AT&T Business Fiber

**Up to 1 GIG speed**

**\$160/mo. plus taxes & fees**

Ltd availability/areas. Price after \$27 mo. discount. Reward card redemption req'd. See offer details

Get a \$500 reward card

Free installation when you order online

**Check availability**

Features and benefits ^

- ✓ Up to 1 GIG upload and download speeds<sup>2</sup>
- ✓ Superfast internet for more efficient work
- ✓ Upload massively large files and collaborate seamlessly via cloud-based apps
- ✓ Online only: Get an additional \$50 reward card when you bundle with AT&T Phone for Business

Get a \$500 reward card

AT&T Business Fiber

**2 GIG speed**

**\$185/mo. plus taxes & fees**

Ltd availability/areas. Reward card redemption req'd. See offer details

Get a \$500 AT&T Visa Reward Card

Free installation when you order online

**Check availability**

Features and benefits ^

- ✓ 2 GIG upload and download speeds<sup>2</sup>
- ✓ A powerful office communication connection
- ✓ Ultrafast speed and bandwidth to support next-gen business and smart office technologies
- ✓ Online only: Get an additional \$50 reward card when you bundle with AT&T Phone for Business

Get a \$500 reward card

AT&T Business Fiber

**5 GIG speed**

**\$250/mo. plus taxes & fees**

Ltd availability/areas. Reward card redemption req'd. See offer details

Get a \$500 AT&T Visa Reward Card

Free installation when you order online

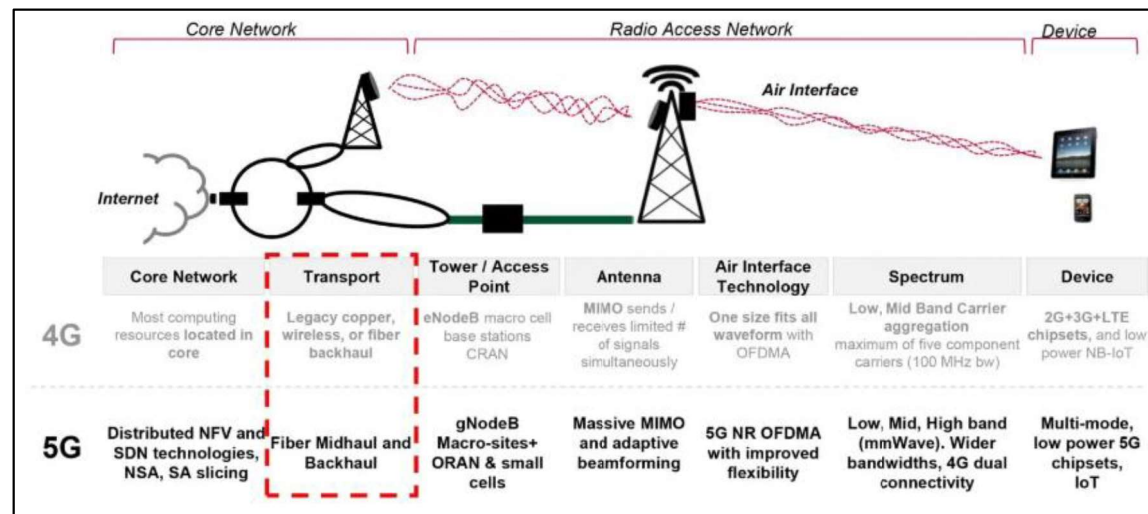
**Check availability**

Features and benefits ^

- ✓ 5 GIG upload and download speeds<sup>2</sup>
- ✓ Supports the most cutting-edge technologies of today and tomorrow
- ✓ Premium speed to keep your business competitive
- ✓ Online only: Get an additional \$50 reward card when you bundle with AT&T Phone for Business

<https://www.att.com/smallbusiness/fiber/> (last visited 9/8/2023).

Additionally, on information and belief, AT&T uses fiber backhaul in its cellular networks. See <https://investor.frontier.com/news/news-details/2023/Frontier-and-ATT-Ink-Deal-to-Deploy-ATT-Wireless-Infrastructure-in-Frontier-Central-Offices/default.aspx> (last visited 9/8/2023). Fiber backhaul is used to support AT&T's wireless networks, including its 4G and 5G networks.



<https://techblog.comsoc.org/2023/02/15/att-to-use-frontiers-fiber-infrastructure-for-4g-5g-backhaul-in-25-states/> (last visited 9/8/2023).

AT&T states that “[w]e operate America’s best and most reliable wireless network. It’s easy to miss, but wireless also depends on fiber. Remember, your smartphone connection is only as fast as the link from a cell tower or other antenna back to the internet. So by design, our wireless traffic promptly moves out of the air and onto our much faster fiber network. This offload improves overall wireless performance, preserves spectrum for strictly mobile applications and cuts the transport cost per-byte.” <https://about.att.com/innovationblog/2022/sambar-fiber-expansion.html> (last visited 9/8/2023).

ITU-T maintains the G.9807.1<sup>1</sup> specification which defines the operation of 10 gigabit symmetric passive optical networks (XGS-PON).

<sup>1</sup> Unless otherwise indicated, all citations to G.9807.1 are to the 06/2016 version.

|                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                     | <div> <p><b>Summary</b></p> <p>Recommendation ITU-T G.9807.1 describes a 10-Gigabit-capable symmetric passive optical network (XGS-PON) system in an optical access network for residential, business, mobile backhaul and other applications. This system operates over a point-to-multipoint optical access infrastructure at the nominal data rate of 10 Gbit/s both in the downstream and the upstream directions. This Recommendation contains the common definitions, acronyms, abbreviations, conventions, general requirements, physical media dependent layer requirements, and transmission convergence layer requirements of the XGS-PON system.</p> </div> <p>G.9807.1 at i.</p> <div> <p><b>3.1.32 passive optical network (PON) system</b> [ITU-T G.987]: A combination of network elements in an ODN-based optical access network that includes an OLT and multiple ONUs and implements a particular coordinated suite of physical medium dependent layer, transmission convergence layer, and management protocols.</p> </div> <p>G.9807.1 at 6.</p> |
| <p><b>1[B]</b> operating an optical network unit (ONU) in a first state in which a transmitter of the ONU is turned off and a receiver of the ONU is turned on;</p> | <p>The Accused Instrumentalities perform the method step of operating an optical network unit (ONU) in a first state in which a transmitter of the ONU is turned off and a receiver of the ONU is turned on.</p> <p>Section C.16 of G.9807.1 details XGS-PON power management:</p> <div> <p><b>C.16 XGS-PON power management</b></p> </div> <p>G.9807.1 at 219.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

This clause addresses three additional means of power management, which does require TC layer support. One is called Doze mode; another is referred to as Cyclic sleep mode; the third is known as Watchful sleep mode. The Watchful sleep mode combines the semantic features of the Doze and Cyclic sleep modes while reusing the states and transition of the Doze mode on the ONU side, and those of the Cyclic sleep mode on the OLT side. To support XG-PON ONUs, the XGS-PON OLT must support all three modes. For XGS-PON ONU, only the Watchful sleep mode needs to be supported.

The TC-layer supported ONU power management modes are negotiated via OMCI, and may be combined with any of the other power reduction techniques.

G.9807.1 at 219

In Supplement 45 (09/2022) to its G series recommendations, the ITU defines the power saving modes mentioned above in G.9807. See G series - Supplement 45 (09/2022) [hereinafter "Supp. 45"] at 20.

When in Doze mode, the ONU powers off the transmitter while the receiver remains on:

**ONU Doze (Dozing)** is associated with additional powering off of the ONU Tx for substantial periods of time on the condition that the Rx remains continuously on. Note the ITU-T recommendations adopted "Doze" mode instead of "Dozing".

Supp. 45 at 20.

The Doze mode is also a component of the Watchful Sleep mode:

**ONU Watchful Sleep mode** collapsing Dozing and Cyclic Sleep in a single state machine has been specified and adopted as replacement since the introduction of XG-PON.

Supp. 45 at 20.

The time during which the Doze state is active within Watchful sleep comprises a first state in which the transmitter of the ONU is turned off and a receiver of the ONU is turned on.

1[C] operating the ONU in a second state in which both the transmitter and the receiver are turned off;

The Accused Instrumentalities perform the method step of operating the ONU in a second state in which both the transmitter and the receiver are turned off.

Section C.16 of G.9807.1 details XGS-PON power management:

### **C.16 XGS-PON power management**

G.9807.1 at 219.

This clause addresses three additional means of power management, which does require TC layer support. One is called **Doze mode**; another is referred to as **Cyclic sleep mode**; the third is known as **Watchful sleep mode**. The Watchful sleep mode combines the semantic features of the Doze and Cyclic sleep modes while reusing the states and transition of the Doze mode on the ONU side, and those of the Cyclic sleep mode on the OLT side. To support XG-PON ONUs, the XGS-PON OLT must support all three modes. For XGS-PON ONU, only the Watchful sleep mode needs to be supported.

The TC-layer supported ONU power management modes are negotiated via OMCI, and may be combined with any of the other power reduction techniques.

G.9807.1 at 219

In Supplement 45 (09/2022) to its G series recommendations, the ITU defines the power saving modes mentioned above in G.9807. *See* Supp. 45 at 20.

When in Cyclic Sleep mode, the ONU powers off both the transmitter and the receiver:

**ONU Cyclic Sleep** means that both ONU Tx and ONU Rx are turned off for preset periods of time with periodic wake up time to check the link status.

Supp. 45 at 20.

The Cyclic Sleep mode is also a component of the Watchful Sleep mode:

|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                           | <div> <p><b>ONU Watchful Sleep mode</b> collapsing Dozing and Cyclic Sleep in a single state machine has been specified and adopted as replacement since the introduction of XG-PON.</p> </div> <p>Supp. 45 at 20.</p> <p>The time during which the Cyclic sleep state is active within Watchful sleep comprises a first state in which both the transmitter and the receiver are turned off.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <p><b>1[D]</b> transitioning the ONU directly from the first state to the second state and transitioning the ONU directly from the second state to the first state, based on a power management rule;</p> | <p>The Accused Instrumentalities perform the method step of transitioning the ONU directly from the first state to the second state and transitioning the ONU directly from the second state to the first state, based on a power management rule.</p> <p>The OLT provides power management parameters to the ONU, such as those listed in Table C.16.1 of G.9807. Such parameters include, for example, Ilowpower, Irxoff, Iaware, and Ihold. <i>See</i> G.9807.1 at 220-21.</p> <p>These parameters are provided to the ONU by the OLT using the OMCI ME object for ONU dynamic power management control.</p> <div> <p><b>9.1.14 ONU dynamic power management control</b></p> <p>This ME models the ONU's ability to enter power conservation modes in cooperation with the OLT in an ITU-T G.987 system. [ITU-T G.987.3] originally specified two alternative modes, doze and cyclic sleep. The subsequent revision of [ITU-T G.987.3] simplified the specification providing a single power conservation mode, watchful sleep.</p> <p>An ONU that supports power conservation modes automatically creates an instance of this ME.</p> </div> <p><i>See</i> G.988 (11/2022) at 91-94 (defining the Managed Entity for ONU dynamic power management control).</p> <p>Most relevant to the discussion below are the Maximum sleep interval and the Maximum receiver-off interval.</p> |

**Maximum sleep interval:** The Isleep/Ilowpower attribute specifies the maximum time the ONU spends in its asleep, listen, or low-power states, as a count of 125  $\mu$ s frames. Local or remote events may truncate the ONU's sojourn in these states. The default value of this attribute is 0. (R, W) (mandatory) (4 bytes)

**Maximum receiver-off interval:** The Irxoff attribute specifies the maximum time the OLT can afford to wait from the moment it decides to wake up an ONU in the low-power state of the watchful sleep mode until the ONU is fully operational, specified as a count of 125  $\mu$ s frames. (R, W) (mandatory) (4 bytes)

G.988 at 92.

The Ilowpower parameter defines the maximum time an ONU can spend in the LowPower state.

**Table C.16.1 – Power management parameters**

| Parameter | Description                                                                                                                                                                                                                                                   | Defined by | Known to |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|----------|
| Ilowpower | Ilowpower is the maximum time the ONU spends in a LowPower state (i.e., Asleep, Listen or Watch state), as a count of 125 microsecond frames. Local wake-up indications (LWIs) or remote events, if detected, may truncate the ONU's sojourn in these states. | OLT        | ONU, OLT |

G.9807.1 at 220. The Ilowpower value is provided to the ONU by the OLT, and it is used by the ONU to establish a Tlowpower parameter controlling a local timer for waking up the ONU to return to an Aware state. *See id.*

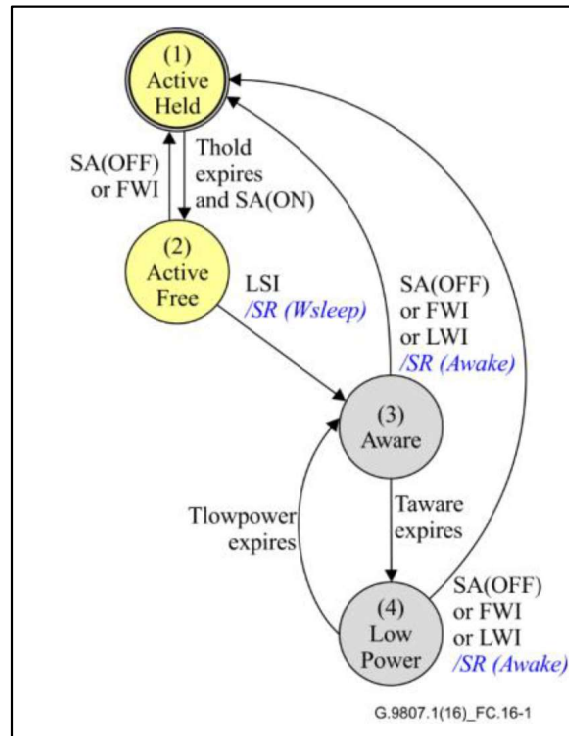
The Irxoff parameter defines the maximum time the OLT needs from the time it decides to wake up an ONU in a lower power mode until the ONU is fully operational.

|        |                                                                                                                                                                                                                                                                                                       |                |          |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------|
|        |                                                                                                                                                                                                                                                                                                       | without delay. |          |
| Irxoff | Irxoff is the maximum time the OLT can afford to wait from the moment it decides to wake up an ONU in one of the low power modes until the ONU is fully operational, specified as a count of 125 microsecond frames. The ONU timer Trxoff and the OLT timer Talerted are initialized based on Irxoff, | OLT            | ONU, OLT |
|        |                                                                                                                                                                                                                                                                                                       |                |          |

G.9807.1 at 221. Further, the “ONU timer Trxoff and the OLT timer Talerted are initialized based on Irxoff.” *Id.* The Trxoff timer, which is based off of a power management parameter, is used by the ONU to ensure that the time between “Watches” (*i.e.*, turning on the Rx to check for wake-up indications) in the LowPower states does not exceed the time dictated by Irxoff. Thus, transitions from the second state to the first state are based on a power management rule that depends on the Irxoff parameter provisioned by the OLT and/or the Trxoff parameter, which is based on Irxoff.

When the ONU is in a “Watching” state of the LowerPower state (*i.e.*, checking for wake-up indications), it must determine whether to transition to the Aware state or to the “Asleep” state of the LowPower state. Assuming no other wake-up indications are present (e.g., Forced wake up indication bits from the OLT or local wake up indication information), the ONU must determine whether it has sufficient time for another sleep cycle before the Tlowpower timer (which is based on the Ilowpower parameter) expires. If enough time exists, then it transitions from the “Watch” state to the “Asleep” state (*i.e.*, first power state to second power state) based on a power management rule that depends on the Irxoff and Ilowpower parameters and/or the Trxoff and Tlowpower parameters.

The above discussion pertains to the activity within the Low Power state. The following diagram illustrates the other power-related states.

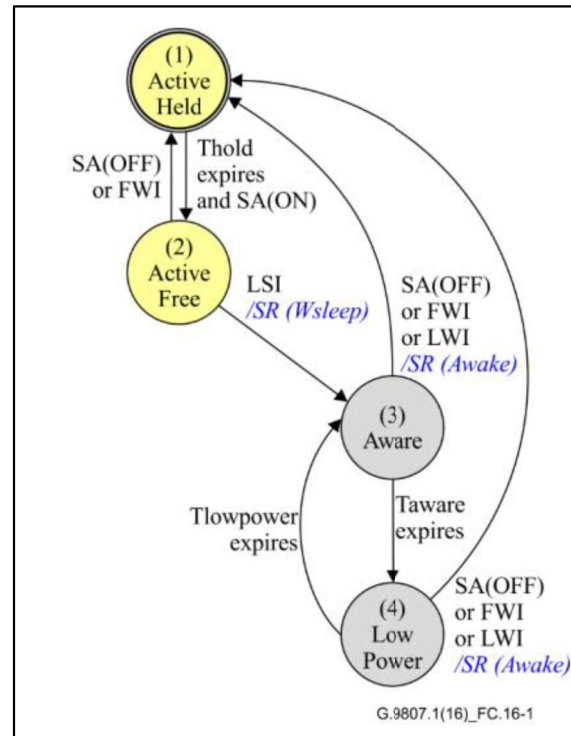


G.9807.1 at 223. Power management rules governing transitions between these states are detailed in the following state transition table.

|                                                                                                                                               | <table><tr><th colspan="5">Table C.16.4 –XGS-PON ONU state transition and output table</th></tr><tr><th rowspan="2">Inputs</th><th colspan="4">ONU power management states</th></tr><tr><th>(1) ActiveHeld</th><th>(2) ActiveFree</th><th>(3) Aware</th><th>(4) LowPower</th></tr><tr><td>FWI</td><td>*</td><td>→ (1)</td><td>→ (1)<br/>/SR(Awake)</td><td>→ (1)<br/>/SR(Awake)</td></tr><tr><td>SA (OFF)</td><td>*</td><td>→ (1)</td><td>→ (1)<br/>/SR(Awake)</td><td>→ (1)<br/>/SR(Awake)</td></tr><tr><td>SA (ON)</td><td>→ (2)<br/>Upon Thold<br/>expiration (Note)</td><td>*</td><td>*</td><td>*</td></tr><tr><td>LWI</td><td>*</td><td>*</td><td>→ (1)<br/>/SR(Awake)</td><td>→ (1)<br/>/SR(Awake)</td></tr><tr><td>LSI</td><td></td><td>→ (3)<br/>/SR(WSleep)</td><td>*</td><td>*</td></tr><tr><td>Tlowpower<br/>expiration</td><td></td><td></td><td></td><td>→ (3)</td></tr><tr><td>Taware expiration</td><td></td><td></td><td>→ (4)</td><td></td></tr></table> <p>G.9807.1 at 224.</p> | Table C.16.4 –XGS-PON ONU state transition and output table |                     |                     |  |  | Inputs | ONU power management states |  |  |  | (1) ActiveHeld | (2) ActiveFree | (3) Aware | (4) LowPower | FWI | * | → (1) | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) | SA (OFF) | * | → (1) | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) | SA (ON) | → (2)<br>Upon Thold<br>expiration (Note) | * | * | * | LWI | * | * | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) | LSI |  | → (3)<br>/SR(WSleep) | * | * | Tlowpower<br>expiration |  |  |  | → (3) | Taware expiration |  |  | → (4) |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------------|---------------------|--|--|--------|-----------------------------|--|--|--|----------------|----------------|-----------|--------------|-----|---|-------|---------------------|---------------------|----------|---|-------|---------------------|---------------------|---------|------------------------------------------|---|---|---|-----|---|---|---------------------|---------------------|-----|--|----------------------|---|---|-------------------------|--|--|--|-------|-------------------|--|--|-------|--|
| Table C.16.4 –XGS-PON ONU state transition and output table                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                     |                     |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| Inputs                                                                                                                                        | ONU power management states                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                             |                     |                     |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
|                                                                                                                                               | (1) ActiveHeld                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | (2) ActiveFree                                              | (3) Aware           | (4) LowPower        |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| FWI                                                                                                                                           | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | → (1)                                                       | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| SA (OFF)                                                                                                                                      | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | → (1)                                                       | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| SA (ON)                                                                                                                                       | → (2)<br>Upon Thold<br>expiration (Note)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | *                                                           | *                   | *                   |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| LWI                                                                                                                                           | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *                                                           | → (1)<br>/SR(Awake) | → (1)<br>/SR(Awake) |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| LSI                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | → (3)<br>/SR(WSleep)                                        | *                   | *                   |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| Tlowpower<br>expiration                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             |                     | → (3)               |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| Taware expiration                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                             | → (4)               |                     |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |
| 1[E] ensuring the ONU is fully powered up, synchronized, and capable of responding to both upstream and downstream traffic and control before | <p>The Accused Instrumentalities perform the method step of ensuring the ONU is fully powered up, synchronized, and capable of responding to both upstream and downstream traffic and control before exiting the first state or the second state.</p> <p>The states detailed above as the first and second states are both part of the LowPower state detailed in the G.9807.1 specification. Once the Tlowpower timer expires, the LowPower state transitions to the</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                             |                     |                     |  |  |        |                             |  |  |  |                |                |           |              |     |   |       |                     |                     |          |   |       |                     |                     |         |                                          |   |   |   |     |   |   |                     |                     |     |  |                      |   |   |                         |  |  |  |       |                   |  |  |       |  |

exiting the first state or the second state; and

Aware state. Additionally, the LWI, FWI, and SA(OFF) cause the ONU to transition to the Active Held state.



G.9807.1 at 223.

As explained regarding the LowPower state, “[b]efore exiting this state, the ONU ensures that it is fully powered up and capable of responding to both upstream and downstream traffic and control.” G.9807.1 at 222 (describing the LowPower state). In order to respond to upstream and downstream traffic and control, the ONU is necessarily synchronized.

1[F] receiving, by the receiver, a power management message from an optical line terminal (OLT); and

The Accused Instrumentalities perform the method step of receiving, by the receiver, a power management message from an optical line terminal (OLT).

The Accused Instrumentalities receive, at an ONU, power management messages from an optical line terminal (OLT), including OMCI messages, PLOAM messages, and an FWI bit.

For instance, OMCI messages are used to manage the ONU dynamic power management control ME as detailed above. *See* 1[D].

The TC-layer supported ONU power management modes are negotiated via OMCI, and may be combined with any of the other power reduction techniques.

G.9807.1 at 219.

The architecture of distributing OMCI messages in an PON using the OMCC is illustrated below.

The OMCI fits into the overall model for an access network system as illustrated in Figure 6.1-1. The dotted line shows a path for OMCI signals between an OLT and ONU.

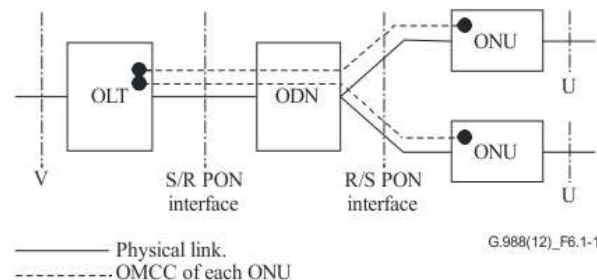


**Figure 6.1-1 – Reference model, OMCI**

G.988 at 15; *see also id.* at 55 (detailing how ME attributes are accessed by the OLT).

Any OMCI message from the OLT updating a parameter for the ONU dynamic power management control ME (Section 9.1.14 of G.9889) constitutes a power management message from an OLT. This

includes OMCI messages updating the Power reduction management mode, Maximum sleep interval, Maximum receiver-off interval, Minimum aware interval, Minimum active held interval, and Maximum sleep interval extension parameters. *See* G.988 at 91-92.

In addition to OMCI, the OLT also uses PLOAM messages to coordinate the operation of the power-based state machines maintained at both the OLT and ONU.

#### C.16.1.1 Power management configuration and signalling

The OLT uses OMCI to discover the ONU's power management capabilities and to configure its power management attributes and modes. To control the power management behaviour of a given ONU, the ONU and the OLT maintain a pair of power management state machines. The ONU state machine and the corresponding OLT state machine operate in partial state alignment. The primary signalling mechanism used to coordinate the ONU and OLT state machines is based on the PLOAM messages. The output PLOAM messages are generated and queued for transmission at the time of state transitions. The states of both ONU and OLT state machines can be classified into two mutually

G.9807.1 at 220. These PLOAM messages include Sleep\_Allow(ON) and Sleep\_Allow(OFF) messages detailed below in Table C.16.3 of G.9807.1, which are power management messages.

Additionally, the transmission of a Forced wake-up indication event by the OLT to the ONU constitutes a power management message.

| Table C.16.3 – XGS-PON ONU state machine inputs |                                 |                                                                                                                                          |
|-------------------------------------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Input categories                                | Input                           | Semantics                                                                                                                                |
| PLOAM events                                    | Sleep_Allow(ON)                 | The OLT grants permission to the ONU to exercise watchful sleep management mode                                                          |
|                                                 | Sleep_Allow(OFF)                | The OLT withholds consent to exercise a power management mode                                                                            |
| Bit-indication event                            | Forced wake-up indication (FWI) | Transmitting FWI as a flag of an allocation structure, the OLT requires immediate ONU wake-up and its transition to the ActiveHeld state |

G.9807.1 at 223.

| 1[G] changing the power management rule based on the received power management message. | <p>The Accused Instrumentalities perform the method step of changing the power management rule based on the received power management message.</p> <p>Each of the power management messages detailed above (1[F]) provide the basis for a change in the power management rule implemented at the ONU.</p> <p>For instance, the Sleep_Allow event determines whether an ONU is permitted to exercise a power management mode. Further, the FWI flag “requires immediate ONU wake-up and its transition to the ActiveHeld state.” Both of these power management messages (PLOAM events and bit-indication events) cause a change in the power rule implemented at the ONU.</p> <table><tr><th colspan="3">Table C.16.3 – XGS-PON ONU state machine inputs</th></tr><tr><th>Input categories</th><th>Input</th><th>Semantics</th></tr><tr><td rowspan="2">PLOAM events</td><td>Sleep_Allow(ON)</td><td>The OLT grants permission to the ONU to exercise watchful sleep management mode</td></tr><tr><td>Sleep_Allow(OFF)</td><td>The OLT withholds consent to exercise a power management mode.</td></tr><tr><td>Bit-indication event</td><td>Forced wake-up indication (FWI)</td><td>Transmitting FWI as a flag of an allocation structure, the OLT requires immediate ONU wake-up and its transition to the ActiveHeld state.</td></tr></table> <p>G.9807.1 at 223. The PLOAM events, as a whole, enable and disable the timers that are used to control the ONU’s power modes (e.g., Tlowpower, Taware, Trxoff). Thus, these power management messages effect a change in the power management rule at the ONU.</p> <p>Additionally, the OMCI messages that alter the Power reduction management mode, Maximum sleep interval, Maximum receiver-off interval, Maximum active held interval, and Maximum sleep interval effect a change in the power management rule implemented at the ONU. Each of these ME parameters, dictated by the OLT, affect the power management rule at the ONU. Thus, any OMCI message changing these parameter values effects a change in the power management rule implemented at the ONU.</p> | Table C.16.3 – XGS-PON ONU state machine inputs                                                                                           |  |  | Input categories | Input | Semantics | PLOAM events | Sleep_Allow(ON) | The OLT grants permission to the ONU to exercise watchful sleep management mode | Sleep_Allow(OFF) | The OLT withholds consent to exercise a power management mode. | Bit-indication event | Forced wake-up indication (FWI) | Transmitting FWI as a flag of an allocation structure, the OLT requires immediate ONU wake-up and its transition to the ActiveHeld state. |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|--|--|------------------|-------|-----------|--------------|-----------------|---------------------------------------------------------------------------------|------------------|----------------------------------------------------------------|----------------------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Table C.16.3 – XGS-PON ONU state machine inputs                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |  |  |                  |       |           |              |                 |                                                                                 |                  |                                                                |                      |                                 |                                                                                                                                           |
| Input categories                                                                        | Input                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Semantics                                                                                                                                 |  |  |                  |       |           |              |                 |                                                                                 |                  |                                                                |                      |                                 |                                                                                                                                           |
| PLOAM events                                                                            | Sleep_Allow(ON)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | The OLT grants permission to the ONU to exercise watchful sleep management mode                                                           |  |  |                  |       |           |              |                 |                                                                                 |                  |                                                                |                      |                                 |                                                                                                                                           |
|                                                                                         | Sleep_Allow(OFF)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | The OLT withholds consent to exercise a power management mode.                                                                            |  |  |                  |       |           |              |                 |                                                                                 |                  |                                                                |                      |                                 |                                                                                                                                           |
| Bit-indication event                                                                    | Forced wake-up indication (FWI)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Transmitting FWI as a flag of an allocation structure, the OLT requires immediate ONU wake-up and its transition to the ActiveHeld state. |  |  |                  |       |           |              |                 |                                                                                 |                  |                                                                |                      |                                 |                                                                                                                                           |



**CLAIM 2****'892 PATENT V. AT&T**

**2[A].** The method of claim 1, further comprising: operating the ONU in a third state in which both the transmitter and the receiver are turned on.

The Accused Instrumentalities implement the method of claim 1, further comprising: operating the ONU in a third state in which both the transmitter and the receiver are turned on.

The ActiveHeld and ActiveFree states are each a third state in which both the transmitter and receiver are turned on.

**Table C.16.2 – XGS-PON ONU power management states**

| State          | Semantics                                                                                                                                                                                                                                                                                                                                                             |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (1) ActiveHeld | The ONU is fully responsive, forwarding downstream traffic and responding to all bandwidth allocations. Power management state transitions do not occur. The minimum sojourn in this state is enforced by the Thold timer. Upon entrance to this state, the ONU sends a Sleep_Request (Awake) PLOAM message. On the state diagrams, this is abbreviated as SR(Awake). |
| (2) ActiveFree | The ONU is fully responsive, forwarding downstream traffic and responding to all bandwidth allocations. Power management state transition requests are a local decision.                                                                                                                                                                                              |

G.9807.1 at 222.

| CLAIM 3                                                                                                                                                                                                                                                                                                                                | '892 PATENT V. AT&T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>3[A].</b> The method of claim 1, wherein the power management rule specifies a first time period for operation in the first state and a second time period for operation in the second state and wherein the transitioning is performed upon expiration of at least one of the first time period and the second time period.</p> | <p>The Accused Instrumentalities implement the method of claim 1, wherein the power management rule specifies a first time period for operation in the first state and a second time period for operation in the second state and wherein the transitioning is performed upon expiration of at least one of the first time period and the second time period.</p> <p>Some of the power management rules detailed above (see 1[D]) depend on power management parameters such as llowpower, lrxoff, laware, and lhold. These parameters are used to determine the maximum sleep interval for an ONU and the maximum receiver-off interval for an ONU.</p> <div style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <p><b>Maximum sleep interval:</b> The Isleep/lowpower attribute specifies the maximum time the ONU spends in its asleep, listen, or low-power states, as a count of 125 <math>\mu</math>s frames. Local or remote events may truncate the ONU's sojourn in these states. The default value of this attribute is 0. (R, W) (mandatory) (4 bytes)</p> <p><b>Maximum receiver-off interval:</b> The lrxoff attribute specifies the maximum time the OLT can afford to wait from the moment it decides to wake up an ONU in the low-power state of the watchful sleep mode until the ONU is fully operational, specified as a count of 125 <math>\mu</math>s frames. (R, W) (mandatory) (4 bytes)</p> </div> <p>G.988 at 92.</p> <p>The llowpower parameter defines the maximum time an ONU can spend in the LowPower state.</p> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                         |                   |                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------------|
| <b>Table C.16.1 – Power management parameters</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                         |                   |                 |
| <b>Parameter</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Description</b>                                                                                                                                                                                                                                                                                                      | <b>Defined by</b> | <b>Known to</b> |
| <b>llopower</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | llopower is the maximum time the ONU spends in a LowPower state (i.e., Asleep, Listen or Watch state), as a count of 125 microsecond frames. Local wake-up indications (LWIs) or remote events, if detected, may truncate the ONU's sojourn in these states.                                                            | <b>OLT</b>        | <b>ONU, OLT</b> |
| <p>G.9807.1 at 220. The llopower value is provided to the ONU by the OLT, and it is used by the ONU to establish a Tlopower parameter controlling a local timer for waking up the ONU to return to an Aware state. <i>See id.</i></p> <p>The Irxoff parameter defines the maximum time the OLT needs from the time it decides to wake up an ONU in a lower power mode until the ONU is fully operational.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                         |                   |                 |
| <b>Irxoff</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | without delay.<br>Irxoff is the maximum time the OLT can afford to wait from the moment it decides to wake up an ONU in one of the low power modes until the ONU is fully operational, specified as a count of 125 microsecond frames. The ONU timer Trxoff and the OLT timer Talerted are initialized based on Irxoff, | <b>OLT</b>        | <b>ONU, OLT</b> |
| <p>G.9807.1 at 221. Further, the “ONU timer Trxoff and the OLT timer Talerted are initialized based on Irxoff.” <i>Id.</i> The Trxoff timer is used by the ONU to ensure that the time between “Watches” (i.e., turning on the Rx to check for wake-up indications) in the LowPower states does not exceed the time dictated by Irxoff. Thus, the Trxoff timer dictates a second time period, which controls the time at which a transition from the second state to the first state should occur.</p> <p>When the ONU is in a “Watching” state of the LowerPower state (i.e., checking for wake-up indications), it must determine whether to transition to the Aware state or to the “Asleep” state of the LowerPower state. Assuming no other wake-up indications are present (e.g., Forced wake up indication bits from the OLT or local wake up indication information), the ONU must determine whether it has sufficient time for another sleep cycle before the Tlopower timer (which is based on the llopower parameter) expires. If enough time exists, then it transitions from the “Watch” state to the “Asleep” state (i.e., first power state to second power state) based on the Tlopower timer. On information and</p> |                                                                                                                                                                                                                                                                                                                         |                   |                 |

|  |                                                                                                                                 |
|--|---------------------------------------------------------------------------------------------------------------------------------|
|  | belief, the ONU relies first time period to determine the time at which to transition from the first state to the second state. |
|--|---------------------------------------------------------------------------------------------------------------------------------|

**CLAIM 5****'892 PATENT V. AT&T**

**5[A].** The method of claim 1, further comprising: performing the transitioning responsive to the received power management message and a local decision to change an operational state.

The Accused Instrumentalities implement the method of claim 1, further comprising: performing the transitioning responsive to the received power management message and a local decision to change an operational state.

In addition to the power management messages detailed above (see 1[F]), the ONU makes local decisions determining whether to maintain low power states or fully wake up. These local events are referred to as local sleep indication (LSI) and local wake-up indication (LWI).

|                                                                                                                                                                                                                                                                                                                                                            | expiration                     | in that state.                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Local events                                                                                                                                                                                                                                                                                                                                               | Local sleep indication (LSI)   | The ONU has no local reason to remain at full power and is willing to exercise the watchful cyclic sleep power management mode. |
|                                                                                                                                                                                                                                                                                                                                                            | Local wake-up indication (LWI) | A local stimulus prevents the ONU from exercising any power management mode.                                                    |
| NOTE – The LSI and LWI events are conceptually derived from the ONU's binary stimulus status level (Awake/Sleep) and correspond to the events of the level change or, in case of ActiveFree state, to the sampled value at the time of the transition. The specific criteria for the local stimulus definition remain out of scope of this Recommendation. |                                |                                                                                                                                 |

G.9807.1 at 223.

Further, the ONU receives the Sleep\_Allow(ON) PLOAM message from the OLT allowing it to enter into the low power state. It then uses internal local timers Tlowpower and Trxoff as described in 1[D] to govern the low power state to ensure the actual duration of the lower power state does not exceed Tlowpower and that it does not remain in an Rx-off/Tx-off mode longer than Irxoff permits.