For larger images or softcopy, contact Wayne Caswell (wcaswell@cazitech.com).

Technical Overview

This presentation is provided by the HomeRF Working Group.
Direct questions or requests for "animated" softcopy to:
HomeRF Communications Chairman, Wayne Caswell
(wcaswell@cazitech.com, 512-335-6073)

Optimizes Tradeoffs for Households

No optimal solution for all applications.
Each must be optimized individually.

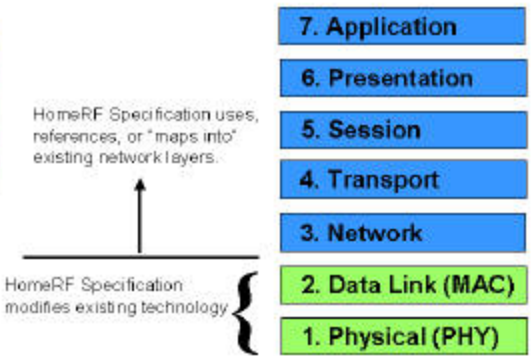
- Interference Immunity
- Power Consumption
- Infrastructure
- Complexity
- Bandwidth
- Licensing
- Size
- Cost
- Absorption
- Reflection
- Latency
- Security
- Range
- Jitter
- QoS

Technical Overview Topics

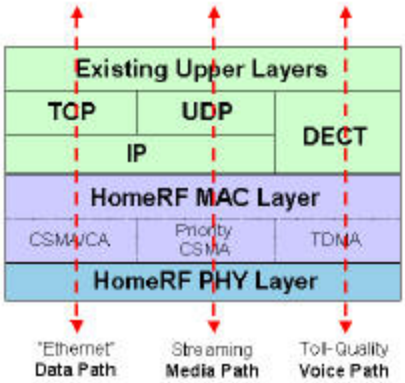
- Toll-quality Voice & Streaming Media
- Data Throughput, Range & Attenuation
- Security & Interference Immunity
- Power Consumption & Form Factor
- Cost

HomeRF Node Types

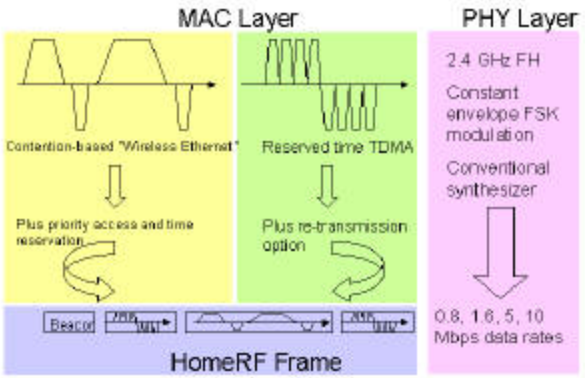
OSI 7-Layer Network Stack Model



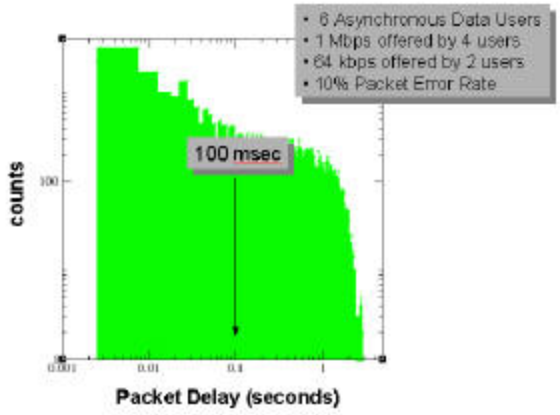
Network Layer View



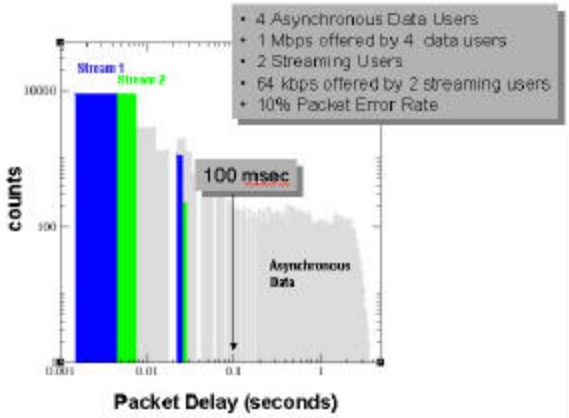
HomeRF Specification Basics



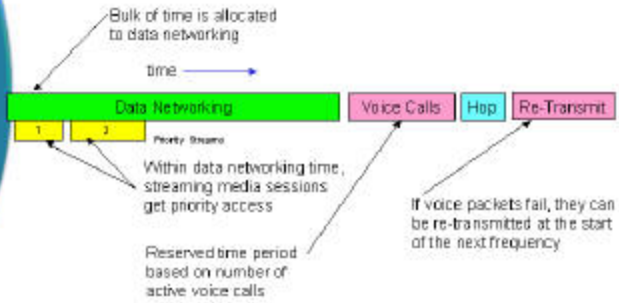
Delay Profile for Asynchronous Data Streams



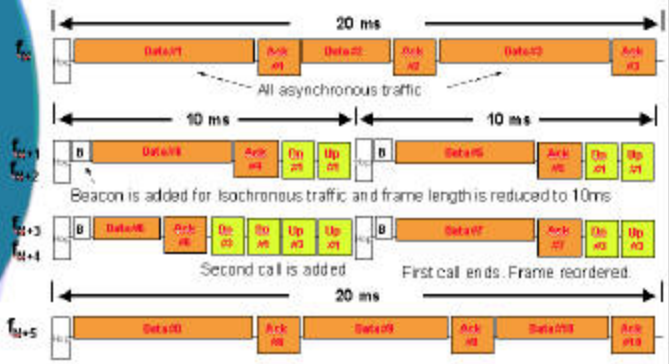
Delay Profile with Simultaneous Asynchronous and Priority Asynchronous



MAC Layer Basics



Superframes and Subframes



High Quality Voice despite Microwave Ovens

Probability of a Hit by Microwave Oven Interference
20% of the band for 50% of the time:
Raw $P_{HIT} \sim 10\%$

Time/Frequency Diversity used to retry voice packets
Independent trials result in:
$P_{2HITS} = P_{HIT}^2 = 1\%$

Hopset Adaption for persistent interferers
Probability of a second hit:
$P_{2HITS} \sim P_{HIT}(P_{HIT}/N) = << 1\%$

Bandwidth Requirements

Application	Speed Required
Text	300 bps
Telephone (QoS, Latency)	8 – 64 Kbps
Color Image	25 – 2,500 K bytes
Digital Photo	1,000 – 10,000 K bytes
Digital Music (QoS)	128 – 700 Kbps
Video Conferencing	384 – 2,000 Kbps
MPEG-4 SDTV VoD (QoS, jitter)	250 – 750 Kbps
MPEG-4 HDTV VoD 720p (QoS, jitter)	4,500 Kbps
MPEG-2 HDTV 1080i (QoS, jitter)	20,000 Kbps

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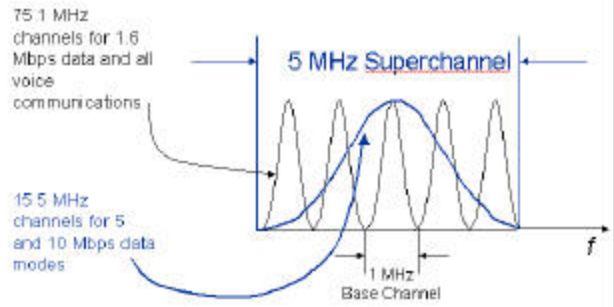
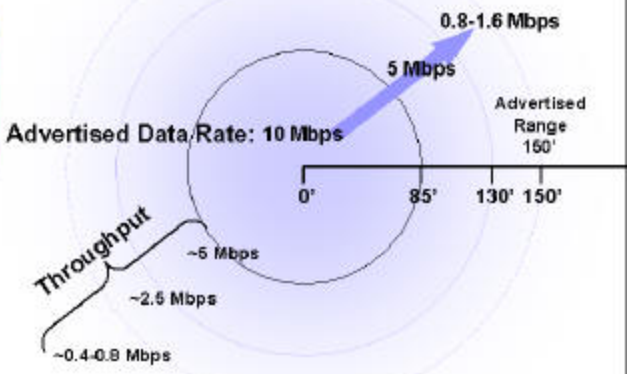
Wideband Frequency Hopping

HomeRF improves performance of 802.11 FH

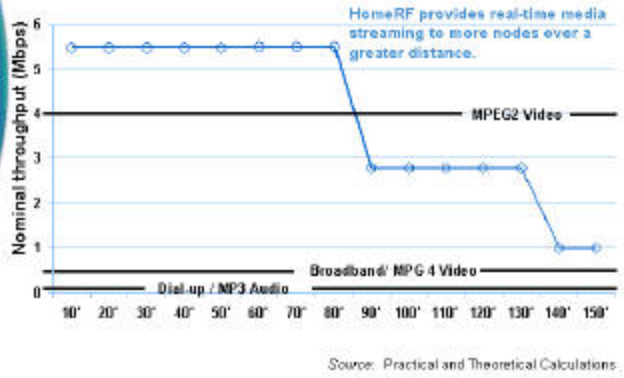
Enabled by FCC rule change in August 2000, ETSI rule change in December 2001



RANGE: Signal Strength Diminishes with Distance

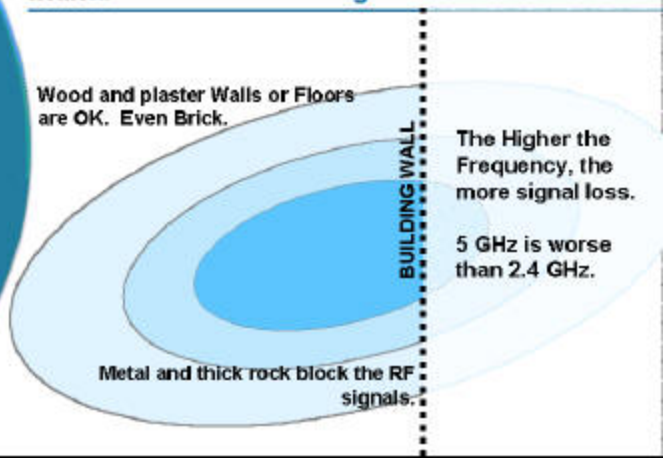


Performance over Distance

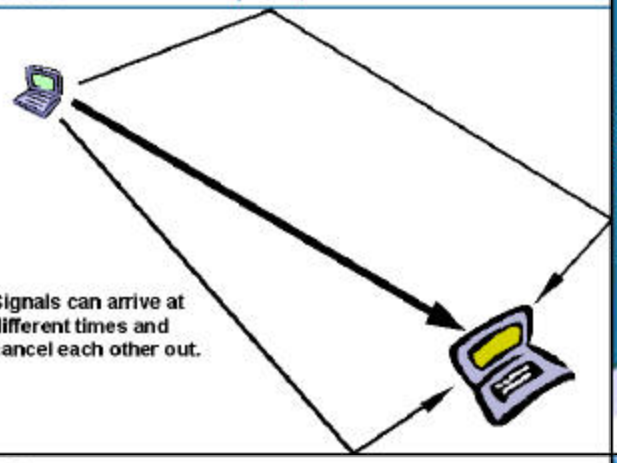


Source: Practical and Theoretical Calculations

Attenuation: Signal Strength Diminishes through Materials



Multi-path in Homes:
More Absorption, Less Reflection



HomeRF Technical Overview Topics

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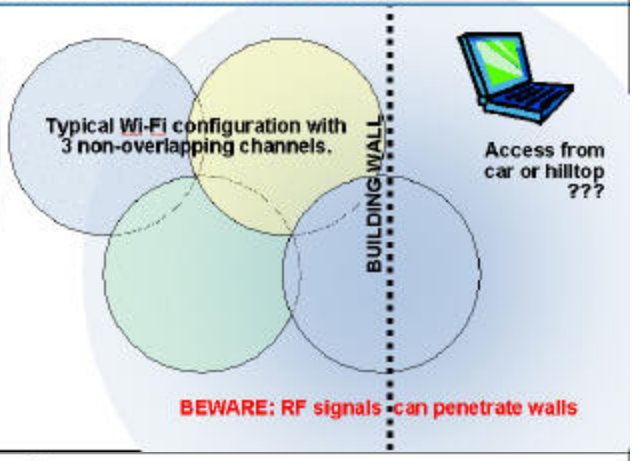
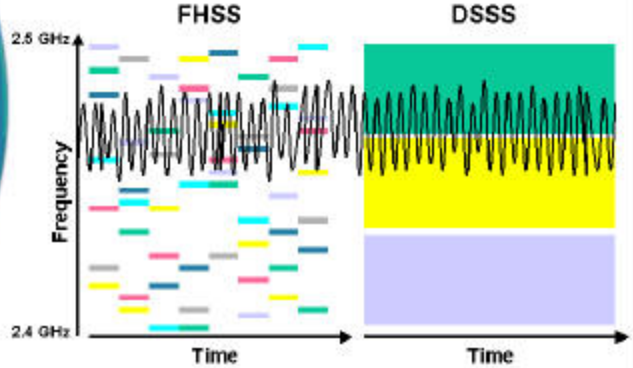
HomeRF is Secure and Reliable

- **Frequency Hopping Spread Spectrum**
  - Invented for the US Military to avoid jamming, denial of service, and eavesdropping
- **Performance with Interference**
  - Microwave ovens, cordless phones, baby monitors, video senders, neighbors
  - High Density Apartments
- **Security Layers**
  - Application Layer Security Option
  - 128-bit Encryption Option
  - Standardized Teach/Learn
  - 24-bit Network ID
  - Random Frequency Hopping
  - Spread-Spectrum
  - Digital

HomeRF is Secure and Reliable

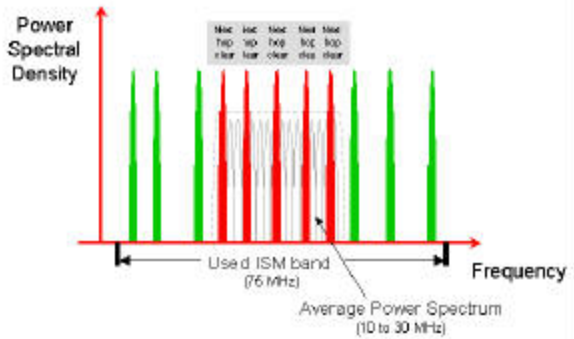


Interference:
HomeRF hops around it

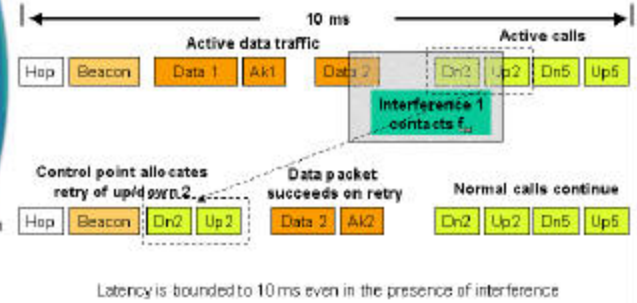


HomeRF Active Interference Avoidance

Spectral / Temporal Characteristics of Microwave Ovens

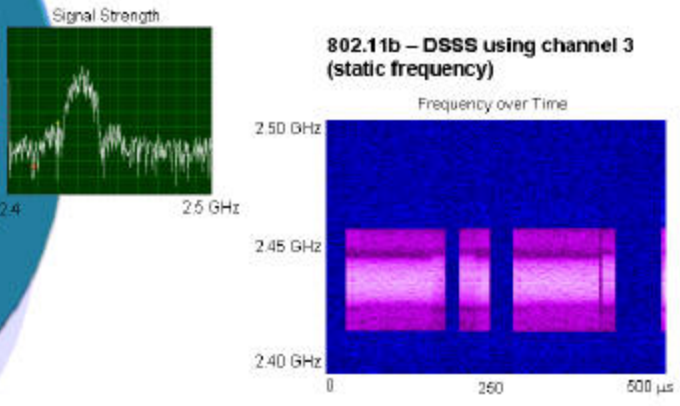


HomeRF Active Interference Avoidance



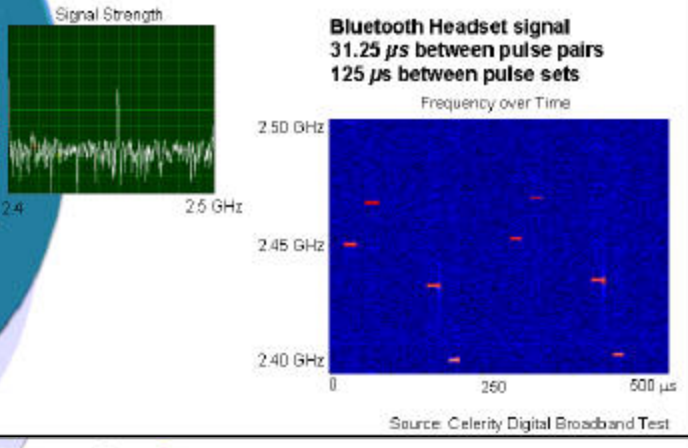
Latency is bounded to 10 ms even in the presence of interference

HomeRF IEEE 802.11b



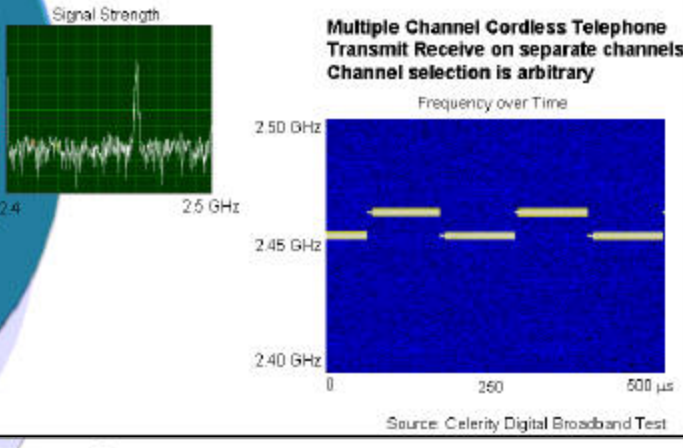
Source: Celerity Digital Broadband Test

HomeRF Bluetooth™



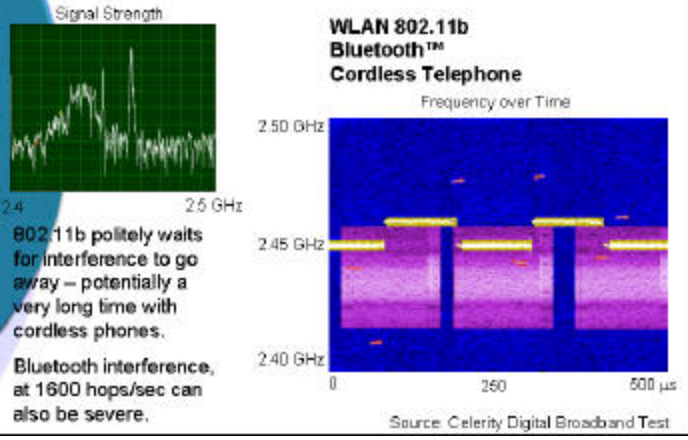
Source: Celerity Digital Broadband Test

HomeRF 2.4 GHz Cordless Phone



Source: Celerity Digital Broadband Test

HomeRF Coexistence within ISM band



802.11b politely waits for interference to go away – potentially a very long time with cordless phones.

Bluetooth interference, at 1600 hops/sec can also be severe.

Source: Celerity Digital Broadband Test

HomeRF Technical Overview Topics

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- Power Consumption & Form Factor
- Cost

Simple Design: enables small form factor for embedded apps

NOT updated for 2.0

- Smallest WLAN form factor
- 1.6 Mbps and full home coverage
- < 10mW standby power draw
- Full TCP/IP connectivity
- Ideal for handheld Internet appliances, personal imaging and audio devices

Specifications:

Physical
- Type II size, < 20 grams
- 0 – 40 degree C operation
- CE, EMC-EEC 89/336 Compliant

Electrical
- 3.3 V, 120mA Rc, 250mA Tx modes
- 3mA standby mode

Hand Held Trends

- Larger, higher resolution Displays with more Colors
- More Performance, Less Cost
  - e.g. Video streaming
- Better Text rendering
- Wireless (WAN, WLAN, PAN)
- PDA becomes Phone, MP3…
- Phone becomes PDA, MP3…
- Digital Imaging
- PocketPC gains some ground
  - Palm still has >70% share

With Microsoft ClearType, palm-sized devices can act as eBooks

Technical Overview Topics

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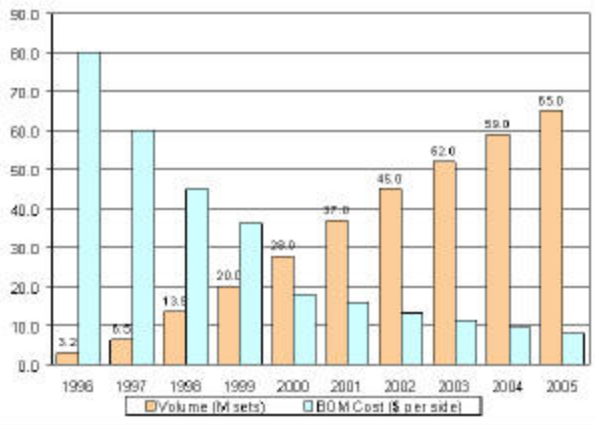
Cost Roadmap parallels DECT

- DECT is a leading indicator for HomeRF
  - 6 generations of architecture evolution
  - HomeRF comes in well down the learning curve
- Complexity is similar
  - HomeRF Baseband ROM/Flash about 2X DECT
  - Radio will reuse Bluetooth/DECT Low-IF IP
- HomeRF BOM cost will approach DECT at same volumes
  - Basic HomeRF functionality (voice + 10Mbps)
  - Additional SW & HW depends on product features

BACKUP

DECT Volume and BOM Cost



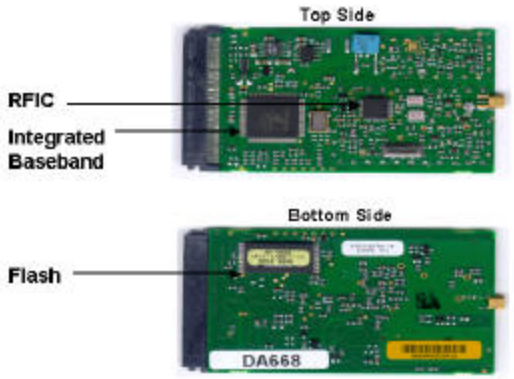
Cost Synergies

- Easy compatibility with OpenAir
  - HomeRF and OpenAir share a common PHY (dual MAC client devices available now)
  - OpenAir has over 1M devices from over 20 different vendors already deployed in the field
- Multi-mode client devices with Bluetooth
  - HomeRF and Bluetooth have similar PHY (multi-MAC client devices, such as a PCMCIA or Compact Flash card, are feasible and expected in 2002)

HomeRF Cost Synergies, cont.

- **Multi-mode / Multi-band clients**
  - PCS / GSM phones
  - 802.11b / .11g (DSSS / OFDM)
  - 802.11b / Bluetooth (DSSS / FHSS)
  - 802.11b / .11a (2.4 / 5 GHz)
  - WLAN / WAN (for mobile workers)
  - Easy to include support for HomeRF
- **Adds much needed Flexibility**
  - Automatically sense and adapt to networks

HomeRF Simple Design: enables Inexpensive 2-chip solutions



HomeRF Summary

- **Ideal for the Broadband (voice, data, entertainment)**
  - Blends several technologies to enable Digital Convergence
  - Broadband data at Ethernet speeds "plus" toll-quality voice and streaming media
- **Designed and optimized for Households & SOHO:**
  - Simplicity, Security/Privacy, Interference, Cost, Applications
- **Smooth roadmap to 20 Mb/s and beyond**
  - Multi-band support for 2.4 GHz and 5 GHz (802.11a)
- **More information at www.HomeRF.org**
  - Learning Center for W.Papers, Presentations, etc.

HomeRF Wireless Choices for the Broadband Internet home

ATTRIBUTE	HomeRF	Bluetooth	802.11b
Cost	✓	~ ✓	✓
Security	✓	~	X
Interference Immunity	✓	✓	X ~
Toll-Quality Voice Support	✓	~	X
Streaming Media Support	✓	~	X ~
Data Throughput	✓	X	✓
Range	✓	X	✓
Power Consumption	✓	✓	X ~
Form Factor	✓	✓	X ~
Network Topology	✓	~	~
Roaming Outside the Home	~	~	~

Legend: ✓ - Advantage | ~ - Adequate | X - Disadvantage