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CONTINUED
SEMINARS IN Hearing

The ABC's of Wireless Connectivity to Hearing Aids

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www.utdallas.edu/hhlab

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Disclosures

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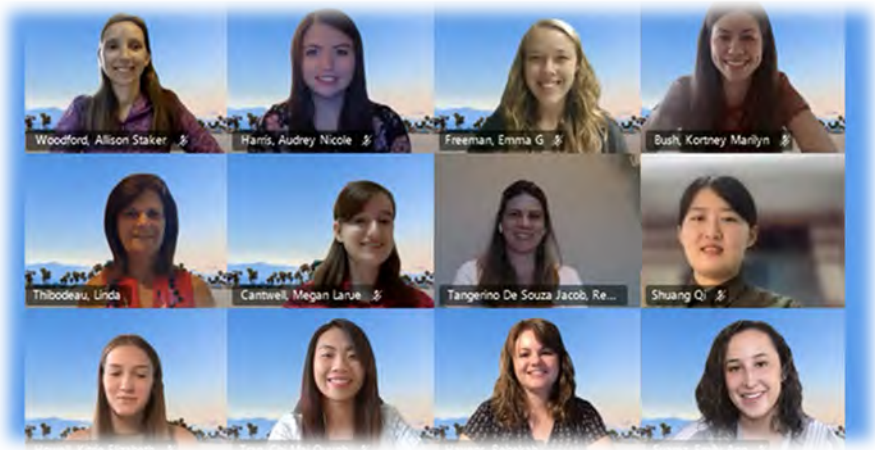
  - UTD Hearing Health Lab



OUTLINE

The variety of options for wireless connectivity to hearing aids will be reviewed. Transmission protocols will be compared with an emphasis on need for creating a "network" of connections to meet the communication demands of the user.

- Introduction
- Rationale
- Transmission Protocols
- Setting up Networks
- Summary, Q & A

After this course, participants will be able to:

- Explain how to determine the need for connectivity to improve communication for HA users.
- Describe the types of wireless transmission for hearing aids.
- Discuss how to determine the optimal network of wireless devices for convenience and maximal benefit.

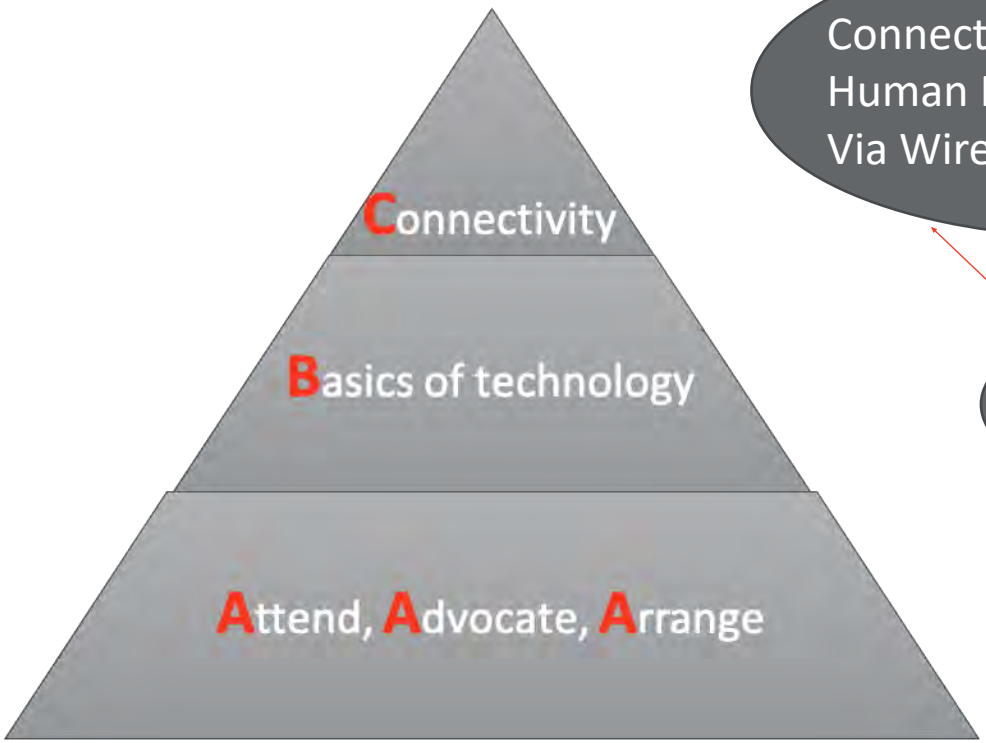
Rationale

- Much of our communication occurs in noisy environments.
- Despite sophisticated circuitry, hearing aids alone are often not enough to achieve optimal communication.
- Many hearing aids now have options for wireless connectivity (beyond t-coil) to devices that can facilitate hearing in noisy environments.

ABCs of Wireless Connectivity to Hearing Aids

- Implies LEARNING THE BASICs
- Implies a foundation upon which to add more knowledge
- Implies a classification of terms/concepts into an organized system for learning

Pyramid of Communication Success
or
ABCs of Communication Success



Connect Human and Non-Human Factors
Via Wireless Connectivity

Non-Human Factors
Personal Ear Level Devices

Human Factors
Determine
needs/preferences

Focus on Connectivity for Interpersonal Communication

- Rather than Large Group Audio Transmission such as Connectivity in a Theatre
- These protocols typically do not have great portability, such as infrared or induction loop systems

Transmission Protocols

Allow connections

between ear-level devices for binaural phone reception with remote microphones to other assistive technology for binaural streaming of music

- Near Field Magnetic Transduction
- Electromagnetic Induction
- Frequency Modulation
- Digital Modulation

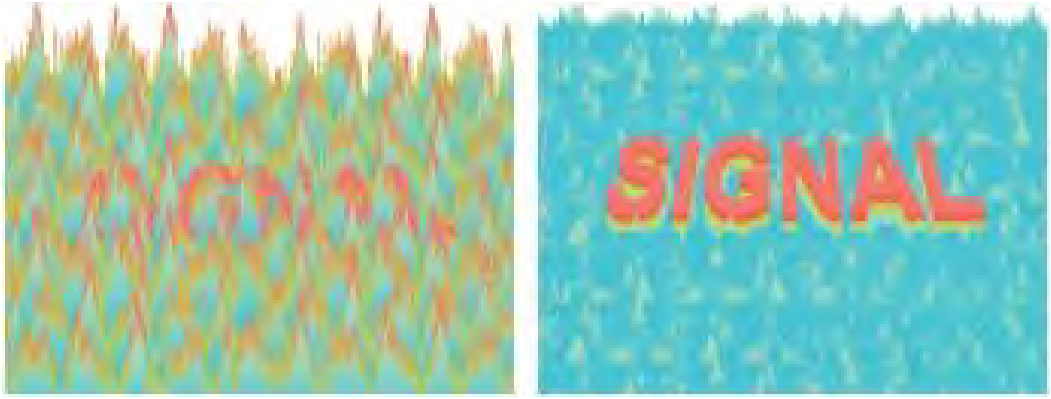
Near Field Magnetic Induction (NFMI)
Communication between Aids to improve Interpersonal Communication in Noisy Environments

- Connectivity Options have increased over the last 10 years Leavitt et al. (2020), Hearstore (2020)
- Data exchange between two hearing aids - Near Field Magnetic Induction (NFMI) Galster (2020)
- Protocol operates in low frequency range (3 to 15 MHz) which allows signal to easily travel through and around the head
  - Allows communication between aids or cochlear implants so that
  - controls on one aid to synchronize program or volume changes
  - signals arriving at each microphone can be compared to determine best settings on each aid to increase the signal-to-noise ratio and improve intelligibility

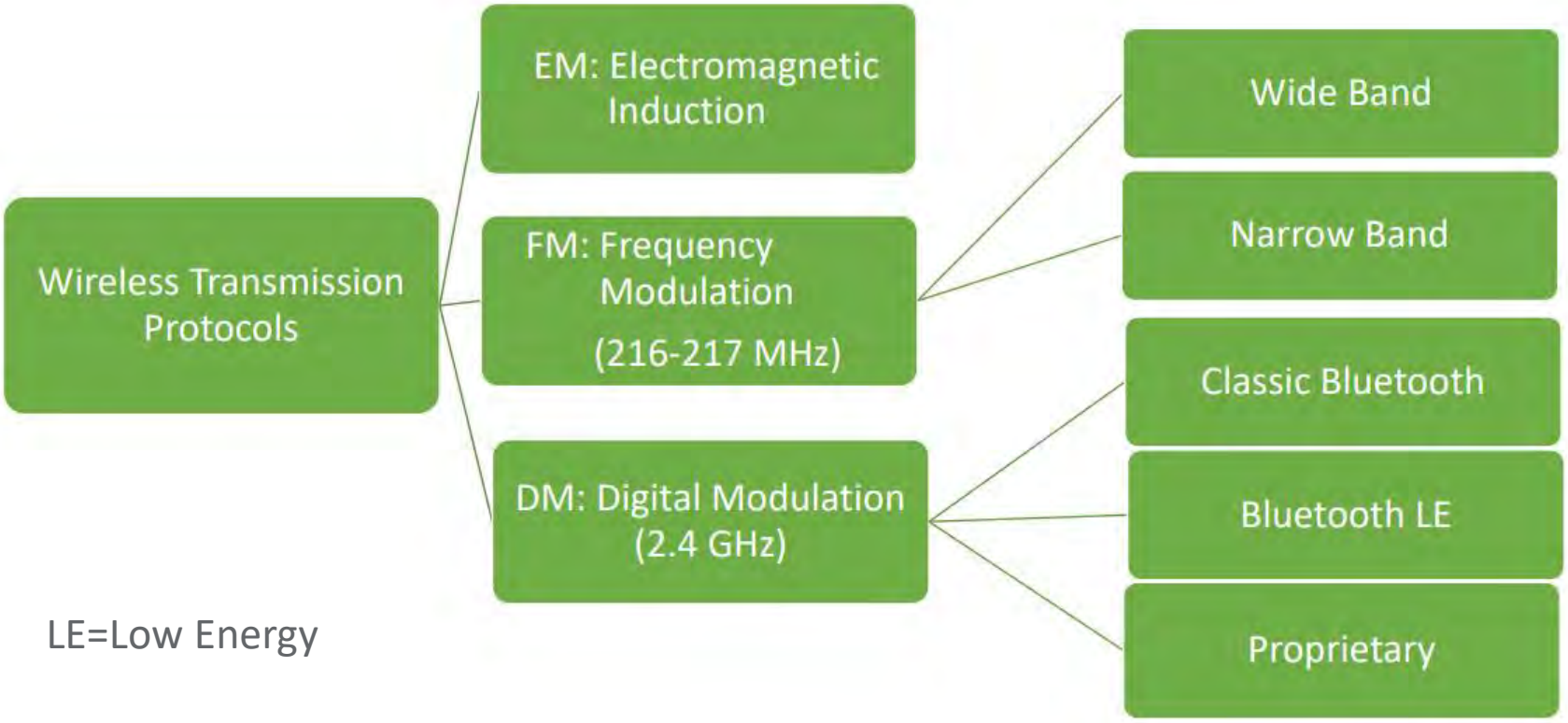
Limitations in Speech Recognition in Noise Remain

SO……

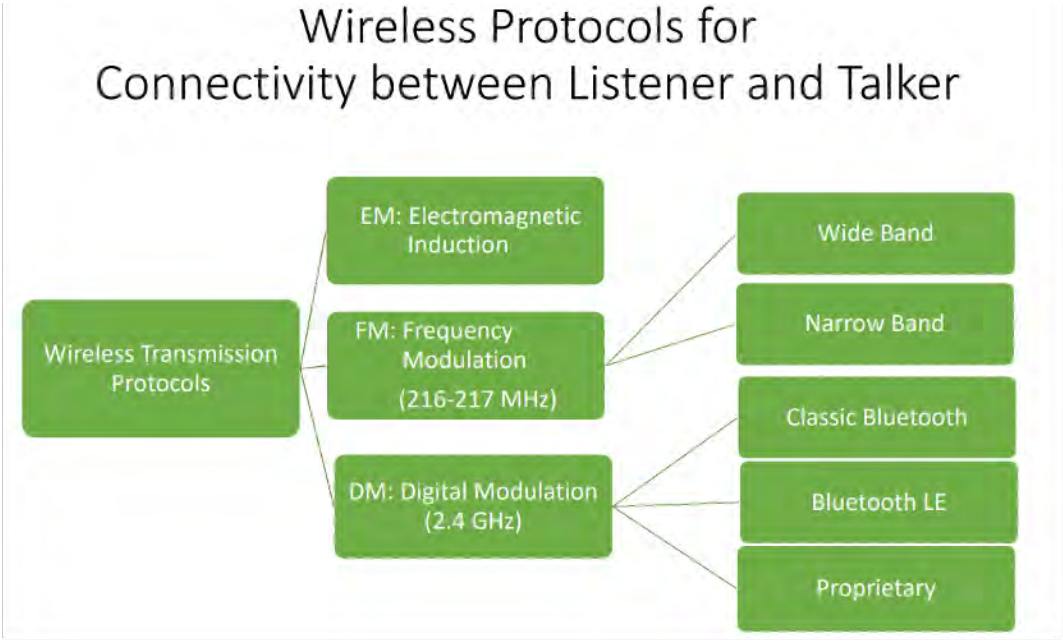
- Let's look at other Wireless options to enhance the signal-to-noise ratio between the listener and the talker(s)

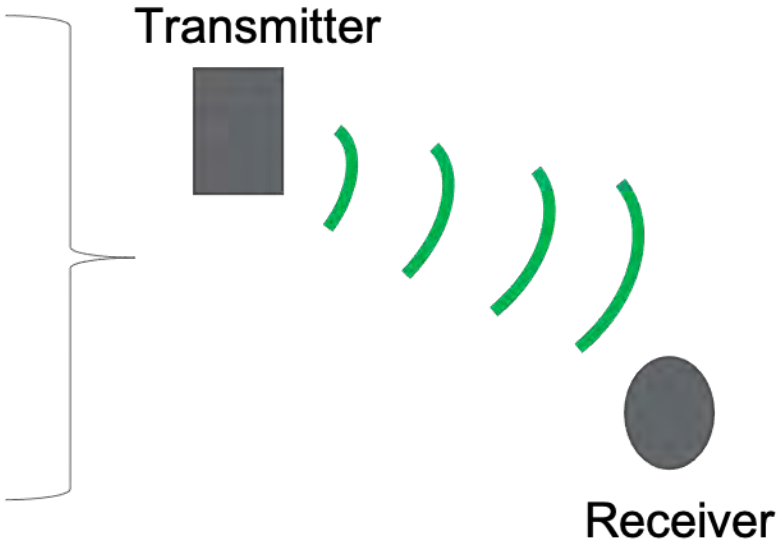


Wireless Protocols for Connectivity between Listener and Talker



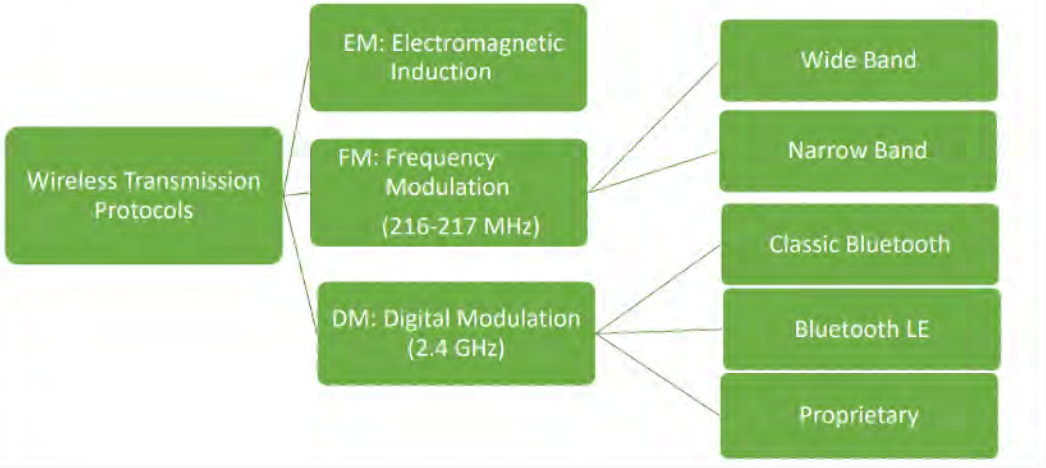
LE=Low Energy

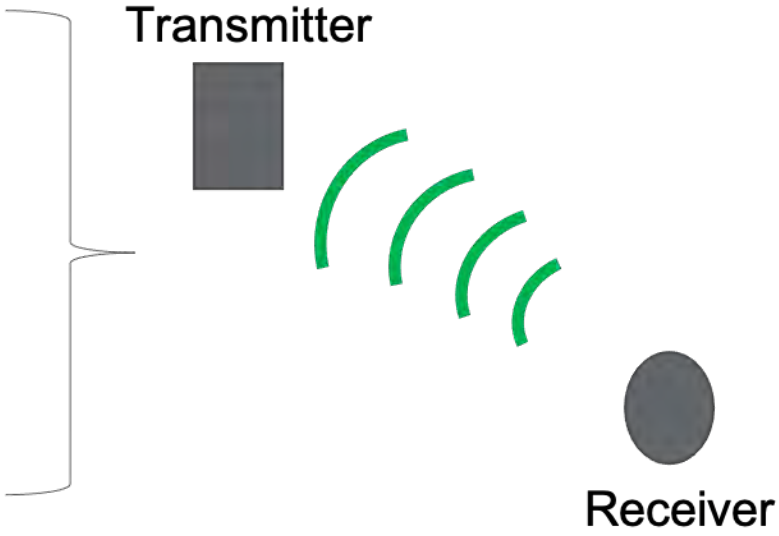




LE=Low Energy

Wireless Protocols for Connectivity between Listener and Talker





LE=Low Energy

Electromagnetic Induction

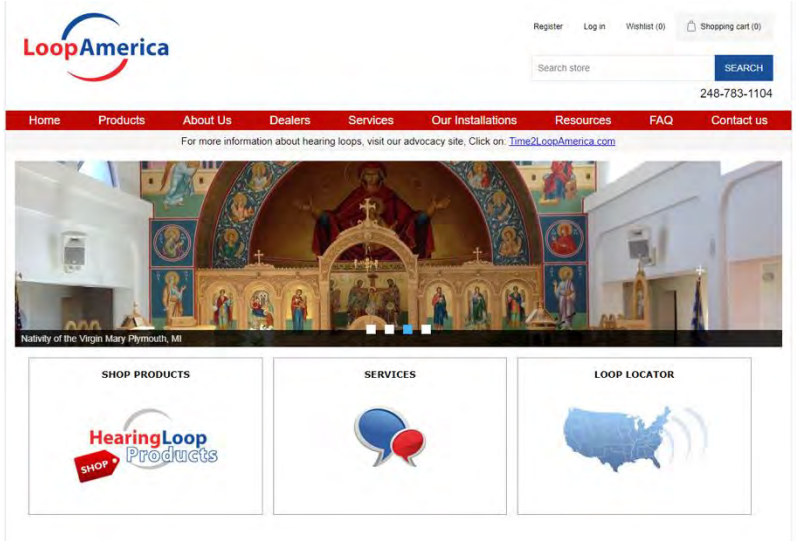
- First wearable hearing aid that contained an induction receiver (i.e., a telecoil) was in 1938 Bauman (2015)
- Wire loop from a transmitter creates an electromagnetic field that mimics the original signal
- When a telecoil gets close to the loop it is sensitive to the changes in the magnetic field and causes a current to flow through the amplifier of the aid
- This results in the signal from the transmitter to be received at a greater intensity than occurs at the arrival of the hearing aid microphone

Multitone VPM Vacuum-tube hearing aid

History of T-Coils—General Information (hearingaidmuseum.com)

Advantages Electromagnetic Induction

- It is universal – Any aid with a Telecoil can receive the signal
- Led to movement “Loop America” (Map Locator – e.g. Michigan 656 entries Texas 50 entries
- Transmission is direct so no need for a carrier signal or worry about matching channels
- Easy to use, no additional parts



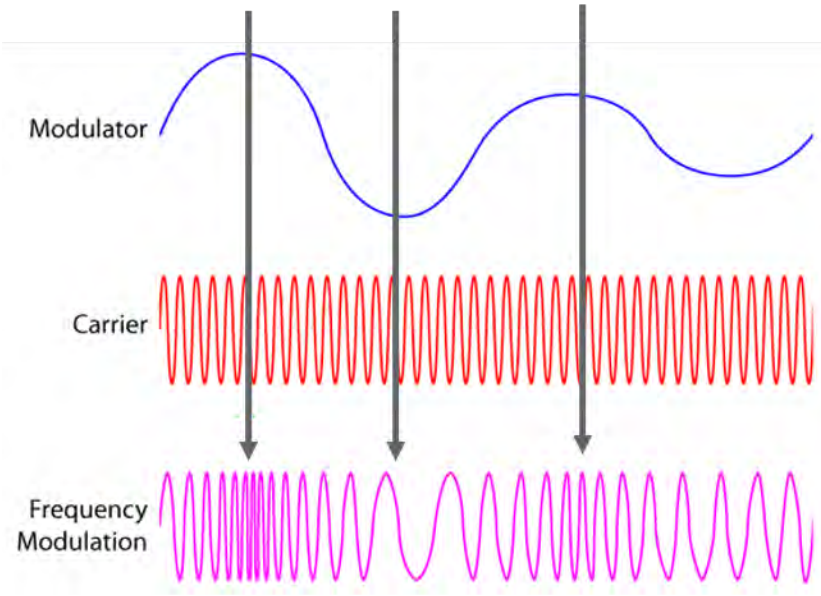
Disadvantages Electromagnetic Induction

- Spillover of the signal from adjacent room loops
- Pickup of stray electromagnetic energy from power lines, computer monitors, and even some smart watches
- Low-frequency energy reduced relative to the original signal
- Tend to be noisy
- Can vary in signal intensity with head movements
- Thibodeau et al. (1990)
- Manufacturers promoting Bluetooth Connectivity

https://hearingreview.com/hearing-products/accessories/assistive-technologies/whats-going-on-more-loops-and-fewer-telecoils

Frequency Modulation

- The transmitter modulates the signal from the microphone via a carrier frequency that is demodulated by a receiver
  - 72 to 76 MHz
  - 216 to 217
- FM systems can operate on either a wide-band or narrow-band range of frequencies.
  - Wide-band carrier frequency are generally less expensive but fewer channels
  - Narrow-band systems may have up to 40 channels but there is overlap so can only use about 6 within a given classroom
- The signal from the microphone is used to modulate the frequencies of the carrier wave such that it corresponds to the original signal
- A receiver tuned to that carrier frequency is needed to demodulate the signal back into the original signal.



ELI5: What is the difference between FM and AM Radio? : explainlikeimfive (reddit.com)

Advantages Frequency Modulation

- Transmitter microphones have sophisticated directionality to enhance noise reduction which results in significant benefits in speech recognition Thibodeau (2010)
- Miniature FM receivers can be attached to most b the-ear hearing aids via an audio shoe or, integrated cochlear implants via an adapter

- FM Receivers can be matched to transmitters easily
- FM Receivers can be integrated into the BTE case or into a neckloop
- FM Receivers can be integrated into ear-level technology for persons with normal hearing or mild loss

Disadvantages Frequency Modulation

- Channels limited to finite number and can get interference if channels overlap
- Receivers draw power from the battery of the hearing aid
  - May reduce battery life 50% if used 12 hours per day

    Reddy and Thibodeau (2018)
- Signal not as clear as next generation digital transmission

  Thibodeau (2014)

Digital Modulation

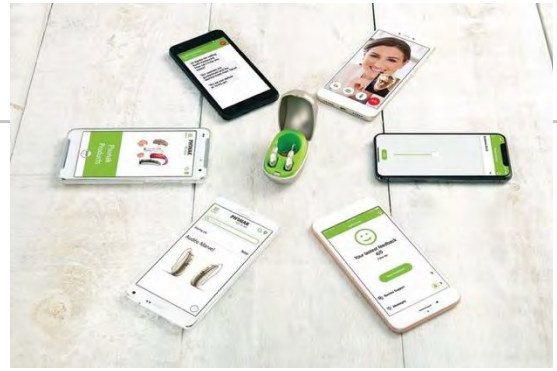
- Operates on the 2.4-GHz frequency band via frequency hopping within the 2.4- GHz frequency band rather than a signal carrier frequency
- DM for use by those with hearing assistive devices was introduced first in 2001
- Some devices contain multiple protocols for transmissions that operate on the 2.4-GHz frequency band
  - Protocols can be standardized – e.g. Bluetooth Classic, Bluetooth Low Energy
  - Protocols can be proprietary – e.g. Phonak Roger, Oticon Streamer, Resound Multi-mic

Digital Modulation

- Bluetooth Classic-Available on
  - Smartphones
  - Computers
  - Intermediary devices such as streamers
- Devices must be paired to communicate with each other
- High power consumption
- Temporal delay in transmission

Digital Modulation

- Bluetooth Low Energy-Available on
  - iPhones
  - MFi (Made for iPhone} Hearing Aids
  - Cochlear implants by Cochlear
- GN ReSound first implemented Bluetooth LE protocol in hearing aids in 2013
- Devices must be paired to communicate with each other
- Low power consumption but reduced range
- Delay in transmission



Digital Modulation

- Proprietary Wireless Protocols -Available on
  - MFA (Made for all Phones) Hearing Aids
  - Specific aids and cochlear implants
  - Intermediary Devices such as Streamers
  - Remote Microphones
- Devices must be paired to communicate with each other
- Low power consumption but reduced range
- Minimal delay in transmission
- May communicate with more than one receiver, e.g. Roger On

Phonak Digital Modulation

- Recognized the need for connectivity to Android phones
  - Android accounted for 88% of phones sold in 2018 (O'Dea, 2020)
- Developed a new DM protocol in 2017 based on a proprietary chip, SWORD, that allowed pairing with Apple or Android phones.
- Phonak aids with SWORD (Sonova Wireless One Radio Digital) chip were referred to as "made for all" or MFA aids
- Unlike the MFi aids, the connection was only between the phone and a SINGLE designated hearing aid.
- In 2018, bilateral phone connection to both iPhone- and Android-based phones was possible in the "Marvel" product line

SWORD Chip – Addressed two issues: Battery consumption and binaural streaming

- SWORD utilizes Bluetooth Classic AND also supports Bluetooth LE
- With improved radio sensitivity, can handle demands of Bluetooth Classic while reducing power consumption and maintaining link stability
- In order to stream to both ears, Phonak developed a dedicated algorithm that extends the Bluetooth capabilities to allow streaming to both ears

What accounts for less power consumption?

- With smaller chips and increases in processing speeds, power consumption can be reduced.
- Smaller transistors on the chip can be more tightly packed so electron movement is more efficient which saves both time and energy.
- With smaller transistors more can be added with more sophisticated features—without increasing battery drain.

SWORD Comparisons

Only chip that is able to simultaneously use

- Bluetooth Classic
- Bluetooth LE and
- Proprietary protocols

SWORD current consumption:

- comparable to MFi hearing aids
- far outperforms the consumer wireless earbuds.

Figure 1: A comparison of the SWORD chip with other Bluetooth solutions. SWORD is by far the best in class in terms of size, area, smallest technology, current consumption, and the number of protocols.

https://www.hearingtracker.com/news/how-phonak-achieved-universal-bluetooth-hearing-aid-connectivity

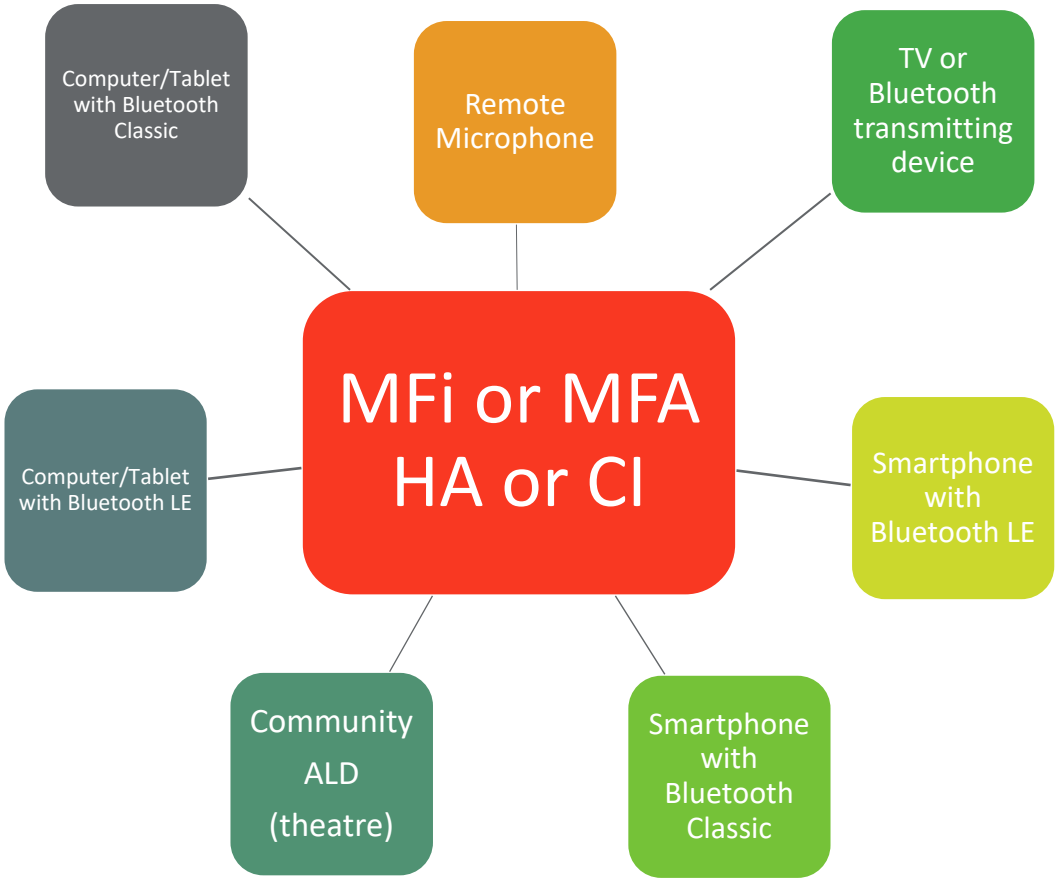
Advantages of Digital Modulation

- Limited Interference
- Unlimited Networks
- High-quality Signal
- Extended Bandwidth
- No searching for available Channels
- Similar to FM Receivers:
  - Miniature DM receivers can be attached to most behind-the-ear hearing aids via an audio shoe or integrated cochlear implants via an adapter
  - DM Receivers can be matched to transmitters easily
  - DM Receivers can be integrated into the BTE case or into a neckloop
  - DM Receivers can be integrated into ear-level technology for persons with normal hearing or mild loss

Disadvantages of Digital Modulation

- Proprietary Network
- Technology upgrades may limit access
- Not all devices have adapters for DM Receivers
- Similar to FM Receivers:
  - Receivers draw power from the battery of the hearing aid but less than with FM

SETTING UP NETWORKS



Questions to Ask to Determine Network Options

- What style of remote mic do they need/prefer – individual use, conference, group settings?
- Do they have a frequent communication partner who would wear a microphone?
- What is the price range they expected to spend?
- What type of Smartphone do they use?
- Are there audio devices other than the smartphone to which they would like to connect, ie TV? Tablet?
- Are multiple chargers OK or keep it simple as possible?
- Can they hear their smoke alarm without wearing their personal device or do they need an alerting app?
- Can they hear sirens while driving?

Sample Network #1

- Nancy has Severe Bilateral Sensorineural hearing loss since birth.
- She is re-entering the workforce after taking care of her medically fragile child who now is entering public school.
- She will be working in an advertising agency where she will give presentations re: ad campaigns.
- Her hobbies include attending the symphony and horseback riding.

Network:

Bilateral Paradise Hearing aids with Roger Receivers installed

Connects aids to GalaxyS10 Smartphone for bilateral phone calls and music streaming

Roger ON Remote Microphone

Husband thinks it's COOL

Prefers to lay Mic near TV because there are several

Gives riding instructor the Roger On to hear better in arena

Connects to Assistive Technology (FM Receivers) via analog audio cable at the Symphony

Uses My RogerMic app on her phone to control Roger ON mic in group meetings

Uses Android Smartphone with apps: Otter for transcription and Sound Alert

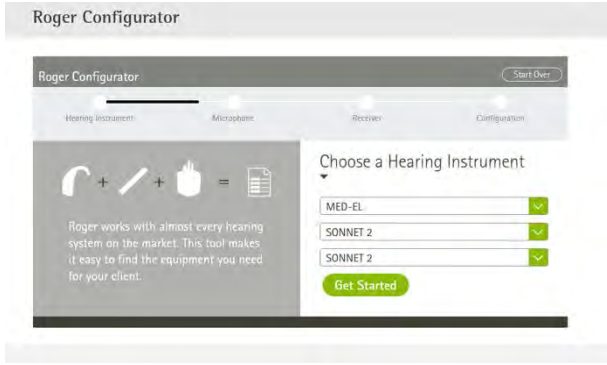
Sample Network #2

- Bill has an asymmetric sensorineural hearing loss.
- He was fit with a MED-EL Sonnet 2 Cochlear Implant on his right ear two years ago and an Oticon OPN 2 RIC on his left ear.
- He is a high school chemistry teacher. His main complaints are hearing his students during small group lab sessions and hearing his wife when they get home after work while they are cooking dinner.
- His school district is willing to purchase anything he needs because he is such an outstanding teacher!

Network:

Right Ear- MED-EL Sonnet 2 CI

Left Ear-OticonOPN 2 RIC



Roger Select Transmitter for use at home while cooking and watching TV

Roger 21 Receiver for MED-EL Implant

Edumic with Roger X(02) Receiver for Oticon OPN 2 RIC aid

6 Roger Select Transmitters for use at each lab table at school

His students know to umute and activate their mic if they want to talk

Select mics set up in a network to transmit to implant/hearing aid

Summary

- Significant speech recognition in noise challenges are encountered despite sophisticated ear-level technology
- Research has shown that remote microphone technology can significantly reduce these challenges
- Wireless connectivity has dramatically improved from electromagnetic induction to FM to DM
- Networks between remote microphones and hearing aids/cochlear implants can be provided to address a variety of communication challenges

THANK YOU FOR YOUR ABC ATTENTION!

- **A**bsolutely
- **B**rilliant
- **C**oncentration

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