Ch1. Applications & Requirements of W. Comm.

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Wireless communications is one of the big engineering success stories.


There are two paths to developing new solutions:

- Engineering Driven.
- Market Driven.
1.1 History: 1.1.1 How It All Started
1.1 History : 1.1.2 The First System

- Need to Bidirectional Communications (Second World War period):
  - Theo. formulation (Claude Shannon, …)
  - The use of CB between drivers on the roads. (100 km/ but lacked to PSTN interface)
  - 1st mobile telephone system in USA (have PSTN interface but not automated / just 6 ch.)
  - AT&T Bell Labs have the solution = cellular concepts.
1.1 History : 1.1.3 Analog Cellular Systems

- **1970s:**
  - Formulation of models for path loss, fading statistics. …
  - Nippon Telephone & Telegraph (NTT) established a commercial cell phone sys in Tokyo.
  - Many countries followed, in USA it is called AMPS.

- **1980s:**
  - At the beginning: the phones were portable but not handheld
  - At the end: it has been a handheld devices.

Now, it seem there is no any further developments.
1.1 History : 1.1.4 GSM & world revolution

- **Analog 2 Digital, why ??:**
  - Analog system has a very bad spectral efficiency.
  - Many Services need the digitality.
- **ETSI group started the developments of digital cellular standard (GSM).**
- **The deployments started at the beginning of 1990.**
- **Many countries followed.**
Wireless Communication, it is not only a cellular communications.

1990s

- Cordless phones.
- Fixed W. Access (WLL,…).
- Others (microwave links, ..etc)

3 G (voice + data) (144kbit/sec to 2 Mbit/sec), to 4G,…etc.

Wireless computer networks
1.1 History: 1.1.6 Wireless Revival:

- Now, it mainly interested in:
  - Cellular system, 2G, 3G, 4G.
  - Wireless Computer Networks.
  - Wireless Sensor Networks.

- Revival, Why?
  - Much broader range of products.
  - Data transmission with high rate.
  - Higher user densities.
1.2 Services: 1.2.1 Broadcasting:

- The first wireless system.
- There are 4 different with cellular system:
  - Unidirectional.
  - The Info. Are same for all users.
  - The Info. Transmitted continuously.
  - In many cases, many Tx. Send same info.

- It has a simple design, why?
  - The Tx. Doesn’t need to have any knowledge about Rx.
  - There is no need to duplex ch.
  - The no. of users doesn’t effect the Tx./structure.
1.2 Services: 1.2.2 Paging:

- The user can only receive not transmit.
- The amount of information is very small.
- The required BW. Is small.
1.2 Services: 1.2.3 Cellular telephony:

- Bidirectional W. Comm. System.
- The user can receive and transmit.
- Voice and Data.
- The required BW. is Large, but it is efficient for the no. of users.
- Complex system.
1.2.4 Trunking Radio:

- It is a complex type of computer controlled radio system which use a few channels and can have virtually unlimited talk groups.
- Group calls.
- Call priorities.
- Relay networks
1.2 Services: 1.2.5 Cordless Telephony:

- Traditional cordless telephony Except the following, it same as cellular:
  - No need to switching.
  - No control system.
  - No charging fees.

- Wireless Private Automatic Branch exchange (W. PABX), (it different from cellular by just coverage and users)
1.2 Services: 1.2.6 WLAN

- Same as Cordless, but:
  - Mobile user = Laptop.
  - PSTN = Internet.
- Main different is the Data Rate
  (in cordless = 64Kbit/sec, but in WLAN = avg = 700kbit/sec).
- Common one, IEEE 802.11
  (a, b, g, n, …)
1.2 Services: 1.2.7 PAN

- Personal Area Network.
  - Coverage (<10m)
  - Low speed but now there is improvement to be 100 Mbit/sec.
  - Main task: cable replacement
  - DVD to TV, mouse to PC, KB to PC…etc
- IEEE 802.15
1.2 Services: 1.2.8 FWA

- Fixed Wireless Access, considered as a cordless system but:
  - No mobility.
  - Normal case, serve many users
- WLL, MVDS, LMDS, etc
- IEEE 802.16
1.2 Services: 1.2.9 Adhoc Network

- It is user equipments based.
- There is no hierarchy.

Features:

- Low cost
- High flexibility.

But:

- Reduce efficiency.
- Smaller range.
- There are restrictions on the no.
  of users.
1.3.1 Data Rate

- **$R$**: is the number of bits that are conveyed or processed per unit of time.

- **In sensor networks**:
  - From sensors to core: few bits/sec to 1 Kbit/sec.
  - But from core to sensors: required high $R$ (#, application)

- **Speech communications**:
  - (5 to 64) Kbit/sec, depending on quality and compression.

- **Elementary data services**: (10 to 100)Kbit/sec.

- **PAN**: 100Mbit/sec.
1.3 Requirements: 1.3.2 Range & #users

- **Range**: is the distance between one TX. And Rx. (not Coverage area)
- **BAN**: 1 meter.
- **PAN**: 10 meter.
- **Cellular**:
  - Micro (500 m)/ Macro (10 to 30km).
  - 5 to 50 users (BW, MA scheme)
- **FWA**:
  - 100 m to several km
  - 5 to 50 (BW, multiple access scheme)
Higher data rate are easier to achieve if the required range is smaller.
1. 3 Requirements: 1.3.3 The Mobility

- **The Mobility**: is the ability to move around while communicating.

- **Mobility degree**:
  - **Fixed**: placed only once.
  - **Nomadic**: placed at a location for a limited duration of time (minute / hour) and then moved to a different location.
  - **Low mobility**: systems can be operated at a pedestrian speeds
  - **High mobility**: systems can be operated at a (30 to 150 km/h).
  - **Extremely high mobility**: systems can be operated at a (300 to 1000 km/h).
Figure 1.8  Data rate versus mobility for various applications.
1. 3 Requirements: 1.3.4 Energy Consumption

- It is an important factor in most of wireless comm. Systems.
- Why??
- To provide a customer satisfaction
  - max mobility duration
- **Important factors:**
  - As distance ++ $\rightarrow$ energy consumption ++
    (SNR must be maintained at Rx.)
  - As amount of data ++ $\rightarrow$ energy consumption ++
    (SNR $\alpha R$)
1.3 Requirements: 1.3.5 Use of Spectrum

Spectrum can be assigned on:

**Exclusive basis**
- Dedicated to 1 service and 1 operator:
  - i.e. Cellular
  - The operator control the freq. plan and interference plan.

**Shared Basis**
- Dedicated to a service but not 1 operator:
  - i.e. Cordless in USA
  - No need to interference plan since the system designed to deal with it. (simple design)
- Free spectrum:
  - Many services, many ops.
  - No need to interference plan since the system designed to deal with it. (complex design)
1. 3 Requirements: 1.3.5 Use of Spectrum

- Two modern frequency usage methods:
  - Ultra Wide Bandwidth (UWB) systems:
  - Adaptive spectral usage:
    - Choose $f$
    - Sense
    - If free
    - Use it
1.3 Requirements: 1.3.6 Direction of Transmission.

- **1. Simplex:**

- **2. Semi-duplex:**

- **3. Full-duplex:**
  - Asymmetric duplex ch.
  - Symmetric duplex ch.
1. 3 Requirements: 1.3.7 Service Quality.

- Required QOS varies according to the type of the service:
  
  - **Speech service**:
    
    - **Speech quality**: measured by mean opinion score (1 to 5).
    
    - **Availability**: measure of blocked calls and dropped calls.
      - Cellular case $\Rightarrow$ fraction of blocked calls +10(fraction of dropped call).
      - Military case $\Rightarrow$ fraction of blocked calls + fraction of dropped call.
    
    - **The admissible delay “ latency “**: measure of the delay between speak and hear.

- **Data services**: measured by bits/sec, the speed of transferring.
Thank You!