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Chapter 1: History

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Learning outcomes

Understand

- which important mechanisms and trends lead to telecom innovations,
- why digital information systems often are preferable,
- different types of information characteristics, and
- what is happening (on a high level) in standardization of 5G.

Hallmarks of telecom innovations

- Usually come out of **several places**
- A full **usable system** must be proposed
- A system must be **financed**
- Must provide a **new major service** (”Killer app”)
- Usually based on **old science**
- Inventors are **problem solvers**, not scientists
- Social effects fully felt only **after 50 years**
- Often **monopolies**, force **standardization**

Technology trends leading to telecom

- Electrical signaling (wires, radio, fiber)
- Microcircuits
- Software
- Scientific understanding (Maxwell, Nyquist, Shannon, et al.)

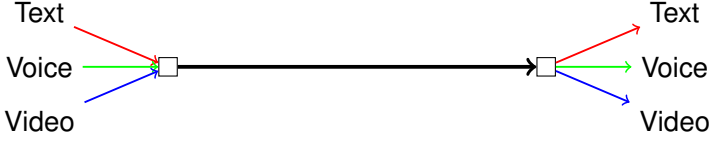
```
for (k=0;k<N,k++){
   /* Do something */
}
```

Why going digital?

- Inexpensive hardware
  - Moore's law: $\text{Cost} = \left(\frac{1}{2}\right)^{\frac{2}{3}\text{years}}$
  - VLSI technology (also for analog circuits)
- New services possible
  - E-banking, email, web, travel booking, distributed lifestyle
- Control of quality
  - When there is a chain of steps $\rightarrow$ Digital better
  - Quality set by number of bits (bit rate)

Why going digital?

- Flexible transport/switching
  - Same format for all
  - Easier, no quality loss



- Interference rejection
  - A lot of interference in wireless communications, e.g., mobile telephony
- Security
  - Much easier in the digital domain

Characteristics of information

- The communication medium
  - Radio (i.e., no medium), electric current, write on paper, smoke
- Delay
  - Letters – days
  - Email – seconds
  - Live radio – milli-seconds
- Quality
  - CD $\rightarrow$ telephone $\rightarrow$ military radio
- Measures
  - Nr. of symbols
  - Meaning (of text, of emotions)
  - Shannon: entropy
- Form
  - Symbols (text, programs, ...)
  - Analog waveforms (voice, video)
  - Feelings

Well known examples

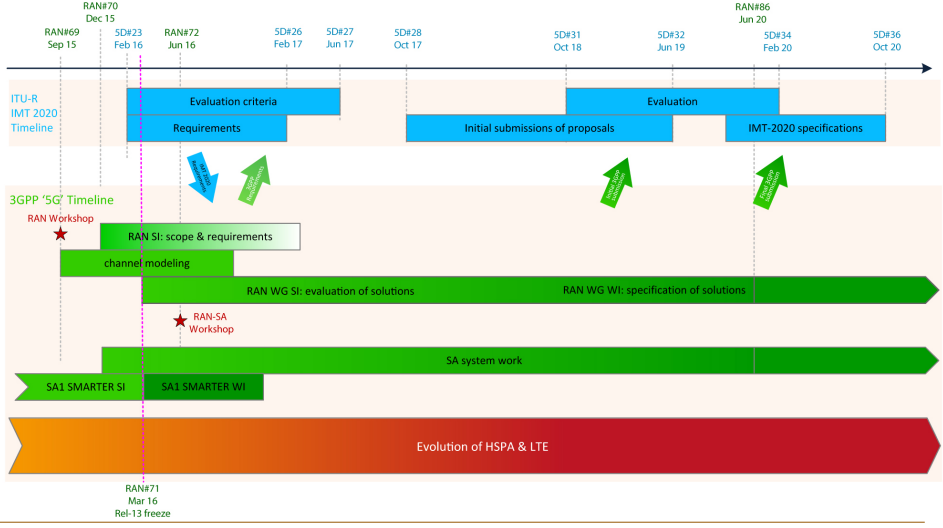
	Telegraph	Telephone	Radio	TV	Internet
Inventor/where	Morse, USA, 1844	Bell, Canada/USA, 1876	Marconi, Italy/England, 1895	Many (extend radio)	Many (DARPA)
Full system	Key, code, wire lines	Telegraph + switching, mic, earphone	Telegraph + spark transm., receiver	CRT, camera, high freq. networks	Rules, packets, PC
How financed?	Line-by-line growth	Switch-by-switch growth	None, set by growth	None, set by growth (government)	None (use existing phone net)
Killer app	Short business messages	... same (but personal)	... same (but-ship-to ship)	Broadcasting	Email & web
Science base	None	None at first, 1915: tube, 1985: fiber	None at first, 1920: tube circuit ideas	Radio & Circuits	VLSI
Inventor's idea	Magnetism "at a distance"	Switching: automation	Wireless telegraph	Radio with pictures	Rules (TCP/IP), packets
Social effects	Wider idea of nation & business, military tactics,	... same + instant & friendly	... same + instant & friendly	Poplulation control, entertainment	???
Monopoly?	US: Western Union, PTT	US: AT&T, SE: Televerket PTT	US: AT&T, SE: Televerket PTT	US:private, SE: SR/SVT PTT	Out of control (almost)

Today: 5G standardization – what happens?

International Telecommunication Union (ITU) has defined a timeline for 5G standardization, known as IMT-2020, but they are not the only one driving the work.

- **3GPP**: The 3rd Generation Partnership Project, contributes to the ITU standard, but they are not alone
- **5G Infrastructure Public Private Partnership (5GPPP)**: Industry academia research consortia
- **Next Generation Mobile Networks (NGMN) Alliance:** includes wireless operators like AT&T, U.S. Cellular and Verizon, aims to include operator voices in the 5G discussion,
- **FCC, ARIB, ETSI ...** : Telecom Standards Institues

Today: 5G standardization – what happens?



LECTURE SUMMARY

- Many things have to be in place for a new innovation to succeed (full system, financed, etc.)
- Trends towards digital: Electrocal signaling, microcircuits, software, ...
- Why digital? Cost, new functionality, control of quality, flexibility, security, ...
- Information: Medium, delay, quality, measure, form, ...
- Today: 5G standardization: What is happening?

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