

ORN

Radio Networks Overview

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*Slides are provided
as supporting tool,
they are not a textbook!*

Outline

1. Introduction to Radio Networks
2. A Historical Perspective

The scope of this lecture block is to provide a high-level overview of fundamentals of Radio Networks,

The *fundamental laws* of radio networks are given.

1. Introduction to RNs

Introduction to RNs

Three fundamental keywords:

- 1) Digital Communications**
 - 2) Radio**
 - 3) Networks**
-

Introduction to RNs: 1) Digital Communications

Introduction to RNs: 1) Digital Communications

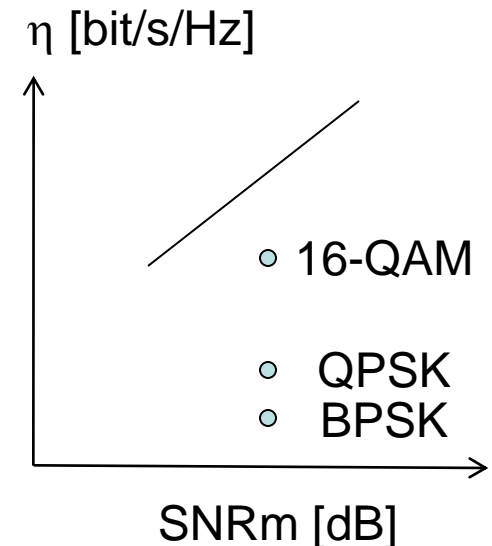
1) Digital Communications → D) Transmission Techniques



Multi-Level/Dimensional Modulation Formats:
bits mapped onto multi-level symbols (L levels),
multi-dimensional signals (D dimensions)

$$B_c > R_s = R_b / D * \log_2(L) \quad [\text{Nyquist, 1928}]$$

$$\eta < D * \log_2(L)$$



Introduction to RNs: 1) Digital Communications

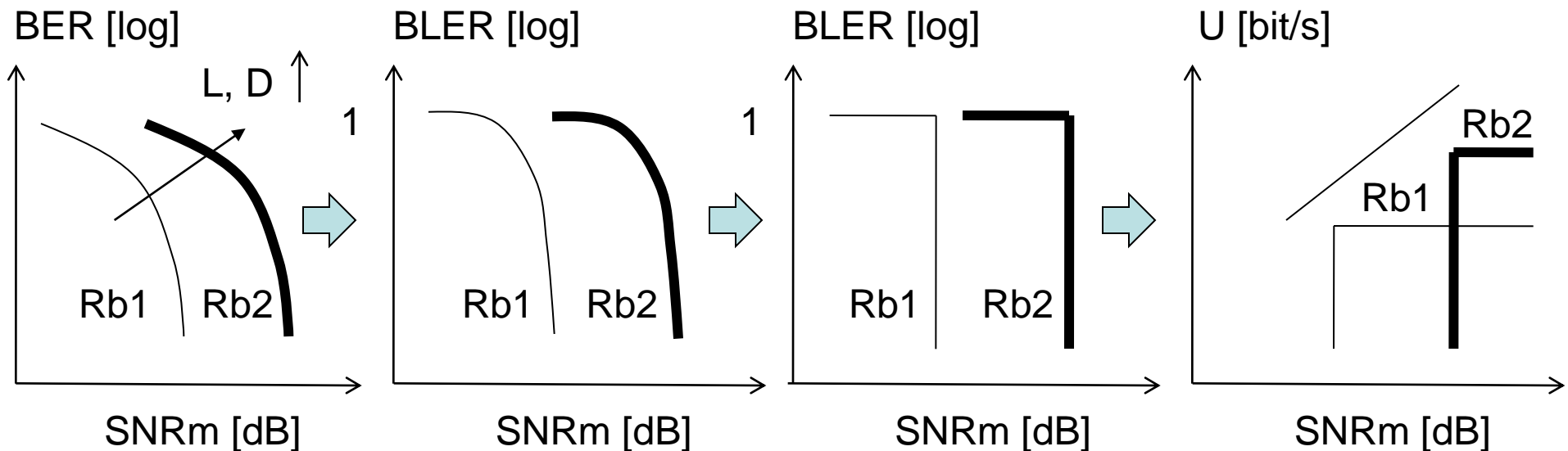
1) Digital Communications → D) Transmission Techniques

B_c is fixed → R_s is fixed

SNR_m BER

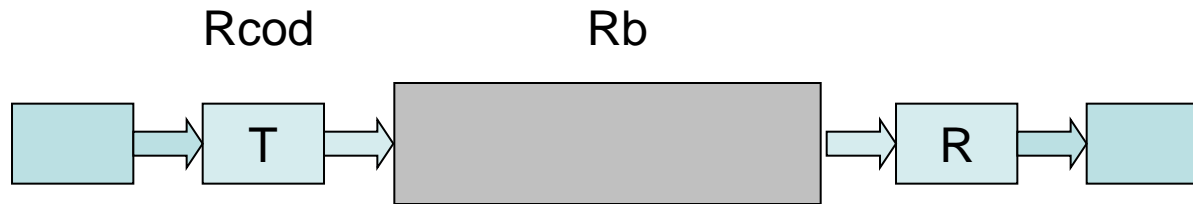


$R_{b2} > R_{b1}$



Introduction to RNs: 1) Digital Communications

1) Digital Communications → D) Transmission Techniques



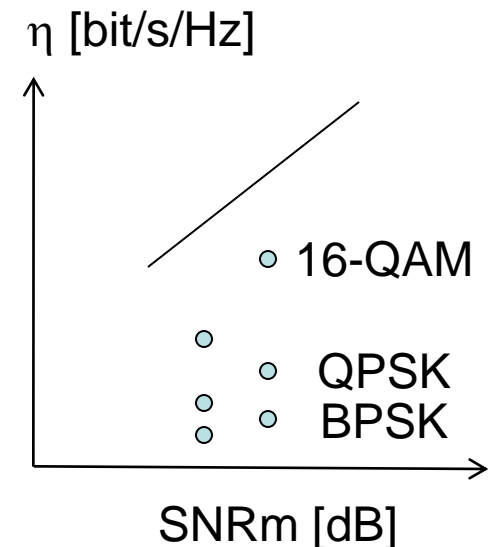
Error Correction Codes:

Redundancy bits added to protect information bits
R is the bit rate before redundancy is added

$$R_{cod} = R / R_b < 1$$

Coding Rate

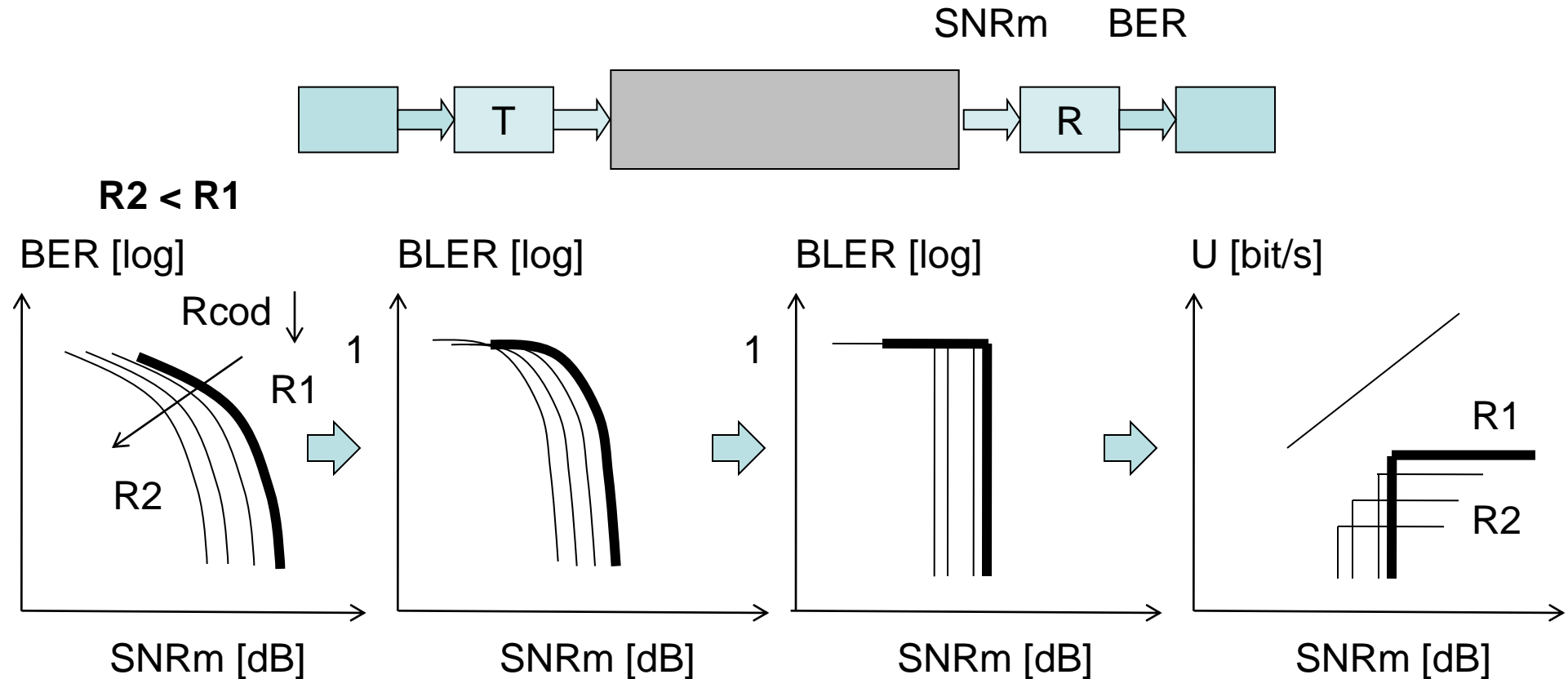
$$\eta < D * \log_2(L) * R_{cod}$$



Introduction to RNs: 1) Digital Communications

1) Digital Communications → D) Transmission Techniques

B_c is fixed → R_s is fixed → R_b is fixed if the modulation format fixed

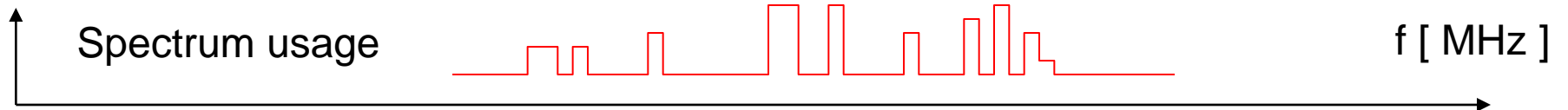
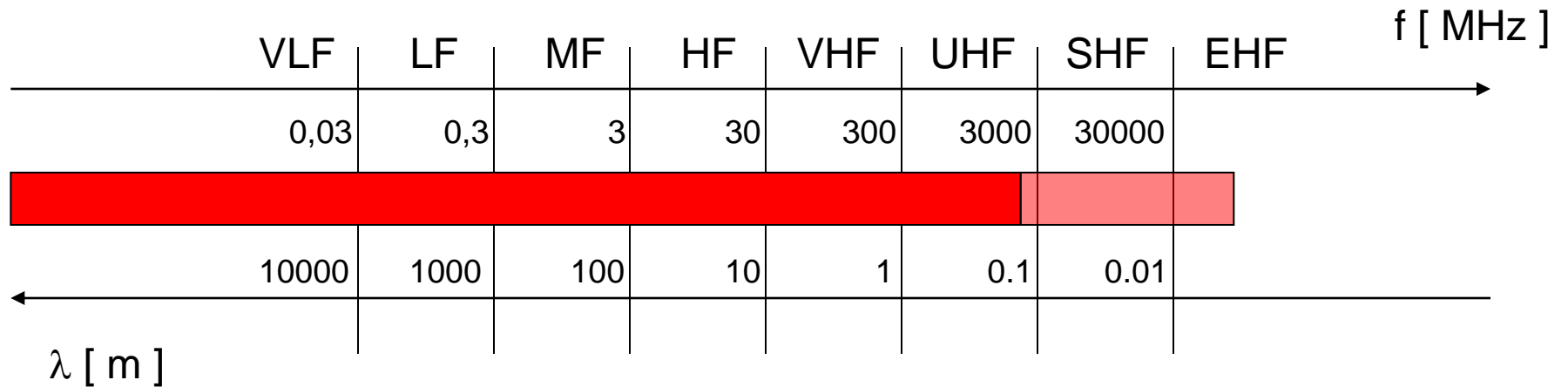


Introduction to RNs: 2) Radio

Introduction to RNs: 2) Radio

2) Radio

→ F) Frequency Spectrum



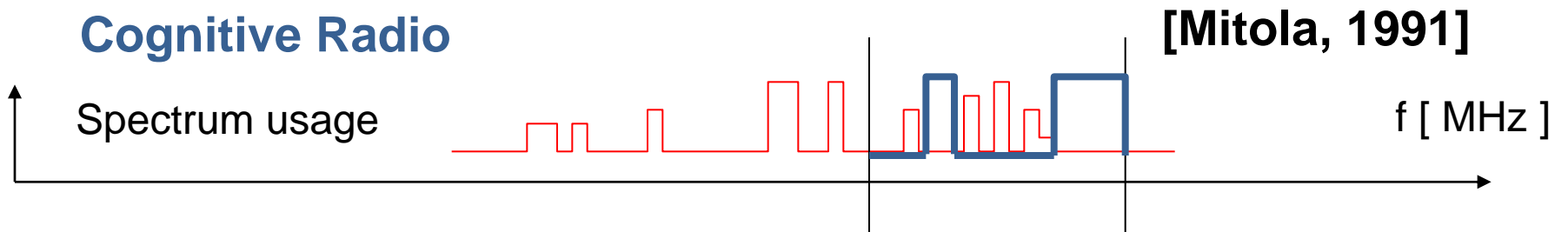
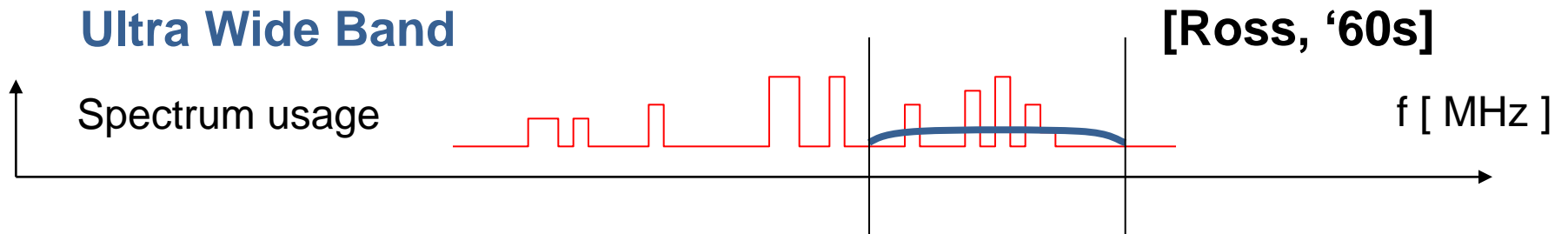
More than 90% is actually unutilised!

Introduction to RNs: 2) Radio

2) Radio



F) Frequency Spectrum



Introduction to RNs: 2) Radio

2) Radio



F) Frequency Spectrum

To cope with spectrum scarcity:

Higher Frequencies

Ultra Wide Band Techniques

Cognitive Radio

Spectrum Sharing

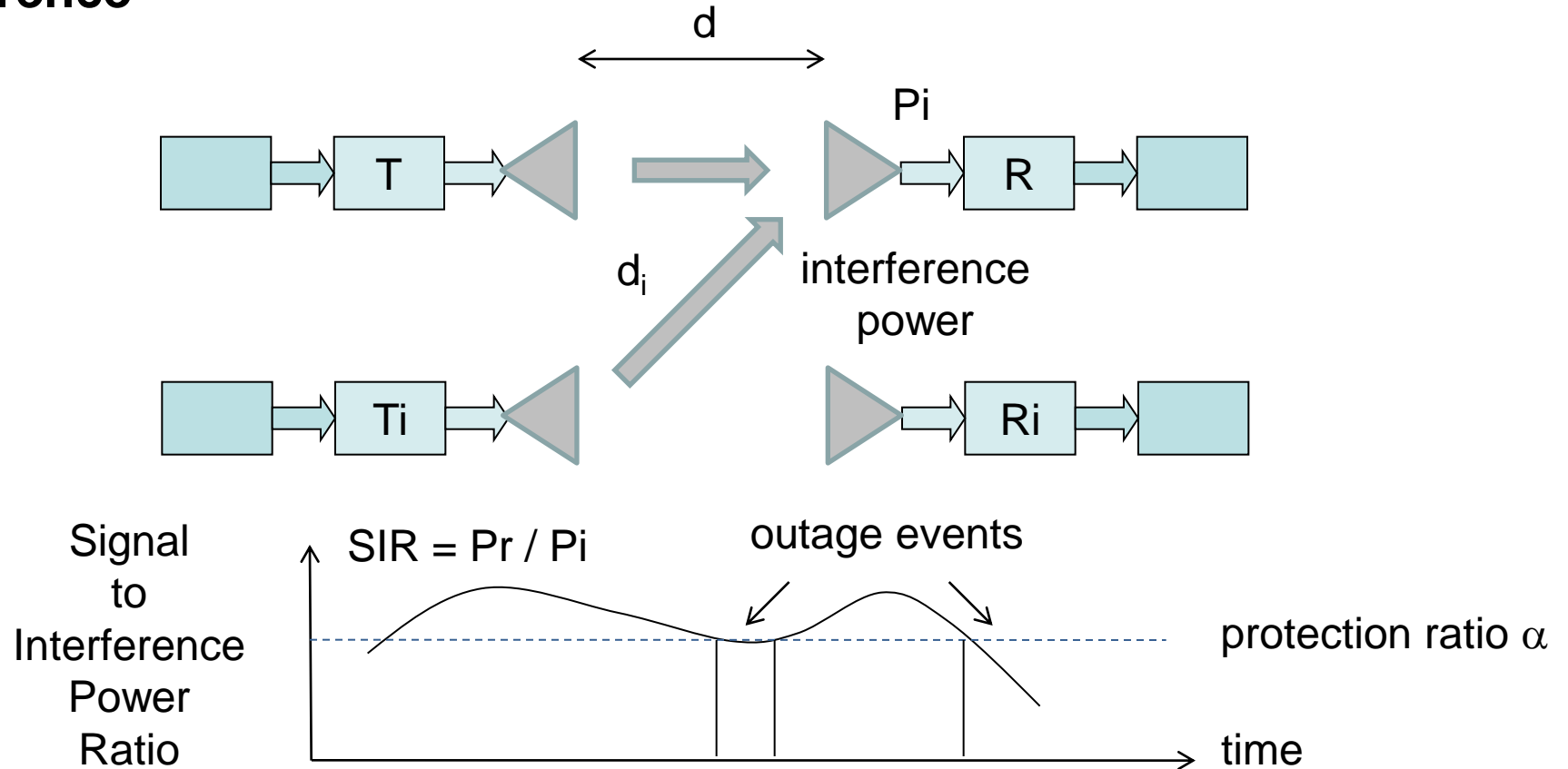
Introduction to RNs: 2) Radio

2) Radio



G) Unpredictable Channel

Interference



Introduction to RNs: 2) Radio

2) Radio



G) Unpredictable Channel

Unreliable Links

$$SIR = k d^{-\beta} \xi / k d_i^{-\beta} \xi_i$$

Reliability requires:

- Countermeasures to channel fluctuations
- Countermeasures to mobility
- Countermeasures against interference

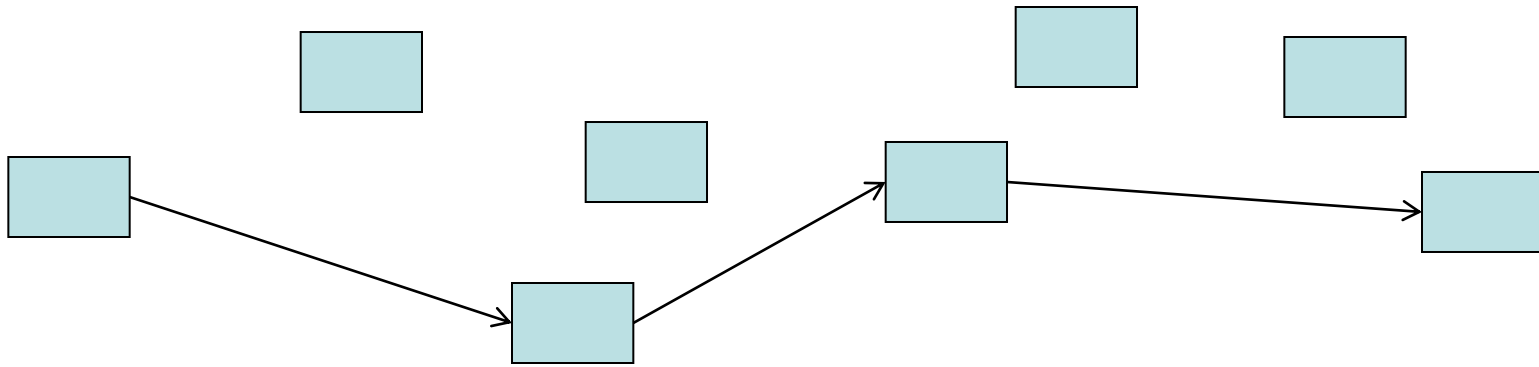
Introduction to RNs: 3) Networks

Introduction to RNs: 3) Networks

3) Networks



M) Network Performance



Path Capacity:

maximum amount of bit rate that can be transmitted over the path with Bit Error Rate zero.

$$C_p = \min [C_i]$$

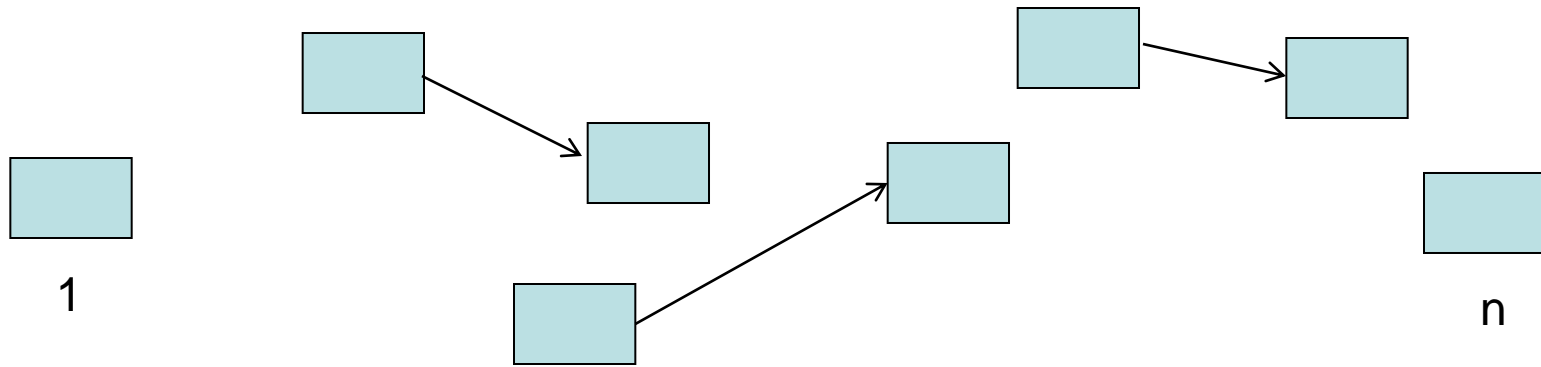
C_p = capacity of the i-th hop of the path

Introduction to RNs: 3) Networks

3) Networks



M) Network Performance



Network Capacity:

maximum amount of *bit-meters per second* [bm/s] that can be transmitted in a random network (square with n randomly uniformly distributed nodes).

C_n is prop to $B_c * \sqrt{n}$

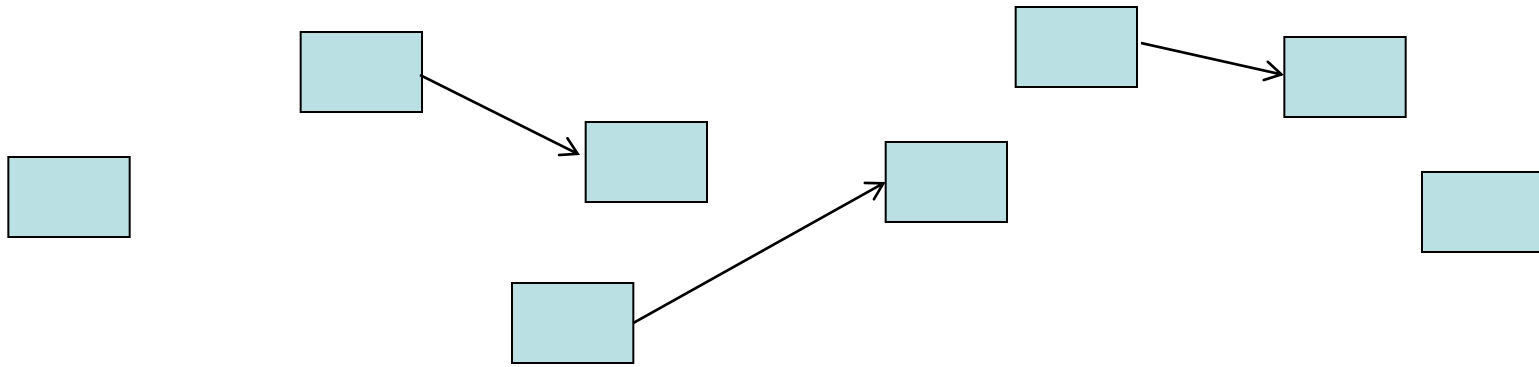
[Gupta, Kumar, 2000]

Introduction to RNs: 3) Networks

3) Networks



M) Network Performance



C_n is prop to $B_c * \text{sqrt}(n)$

More Connected Devices →

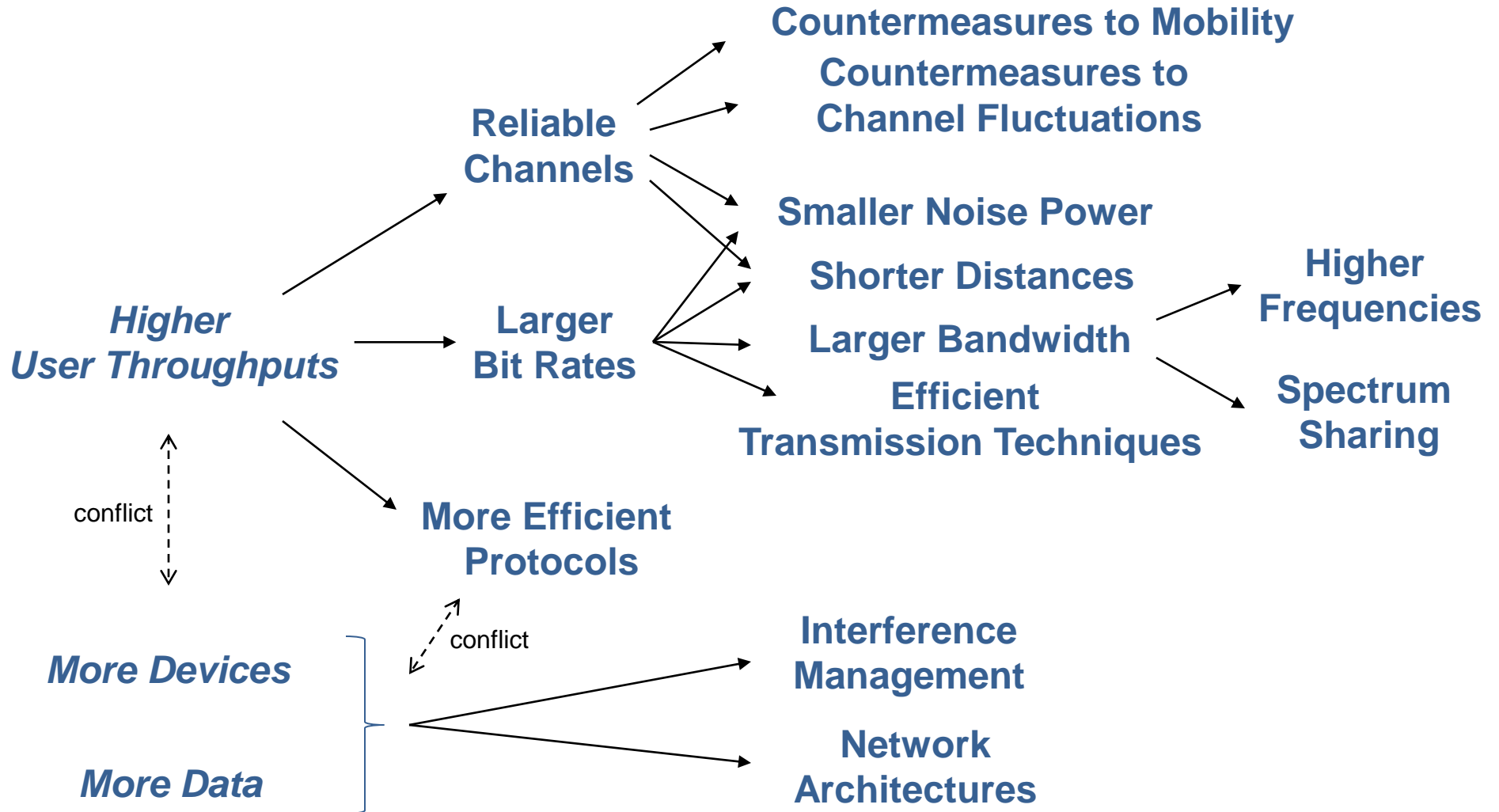
Higher Overall Throughput
Lower User Throughputs

$C_p = \min [C_i]$

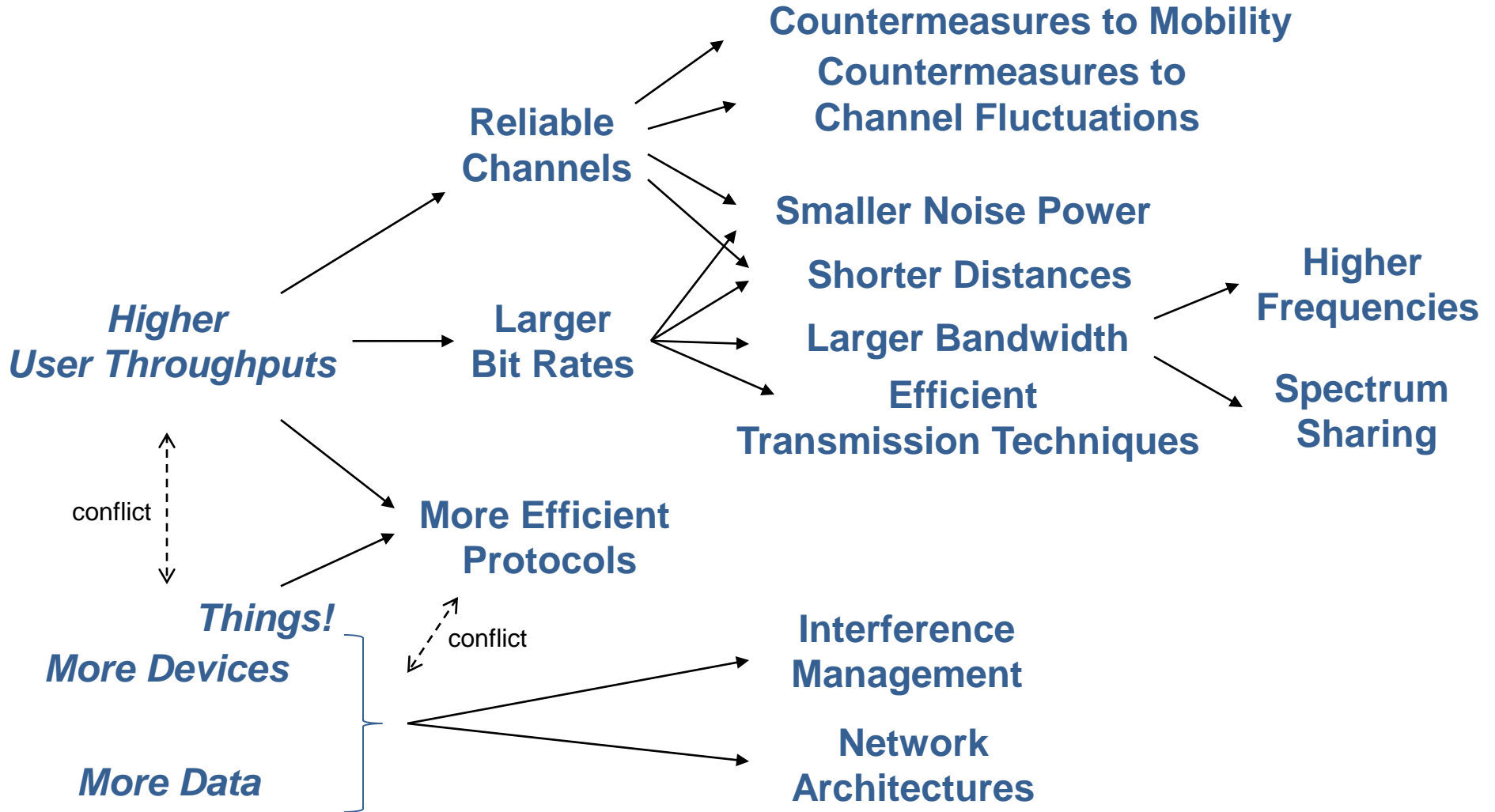
Shorter Links →

Higher Overall Throughput

Introduction to RNs: Summary

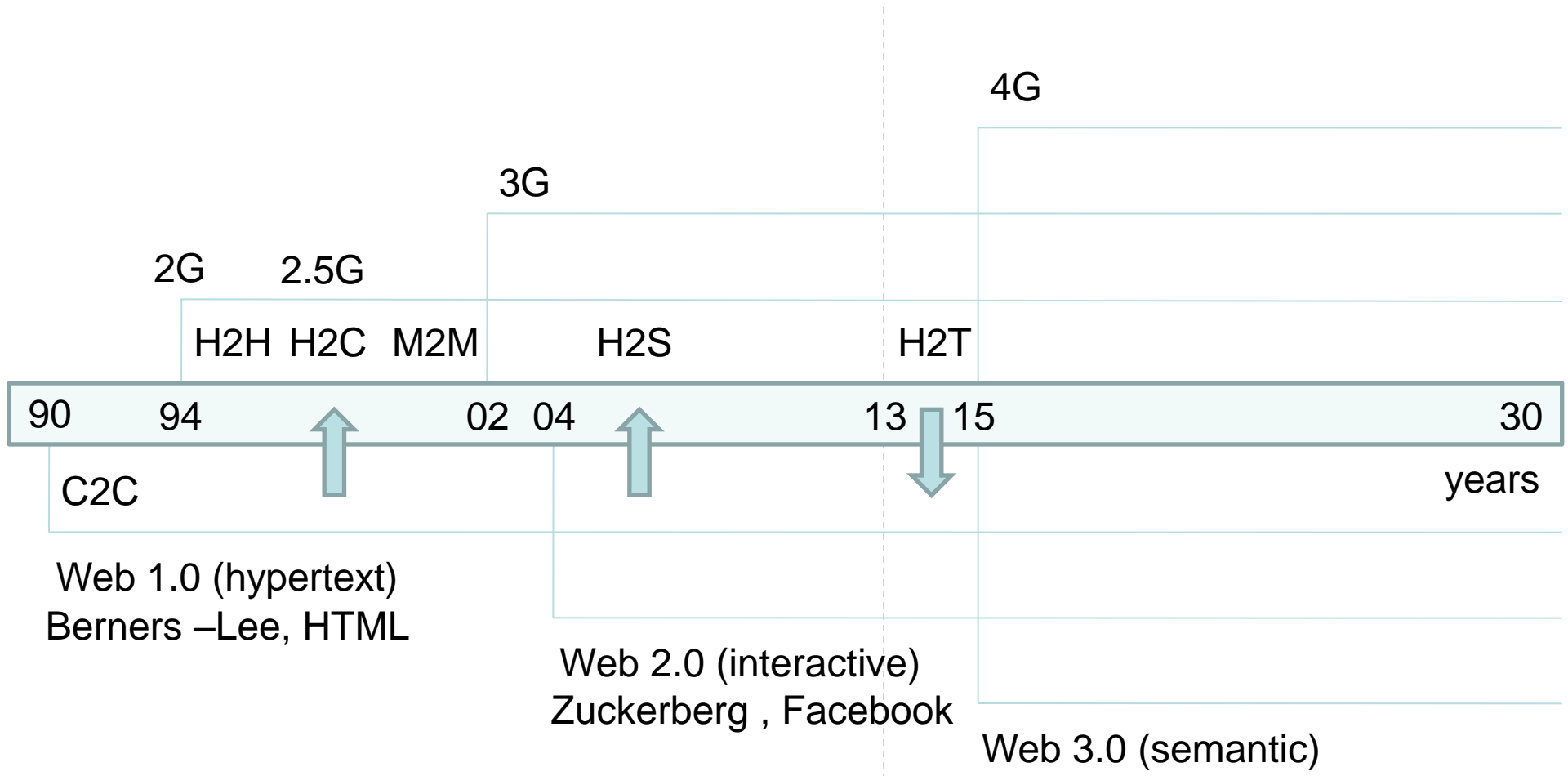


Introduction to RNs: Summary



2. Historical Perspective

Radio Communication Standards and the Web: Historical Perspective (Digital Era)



Radio Communication Standards: Evolution

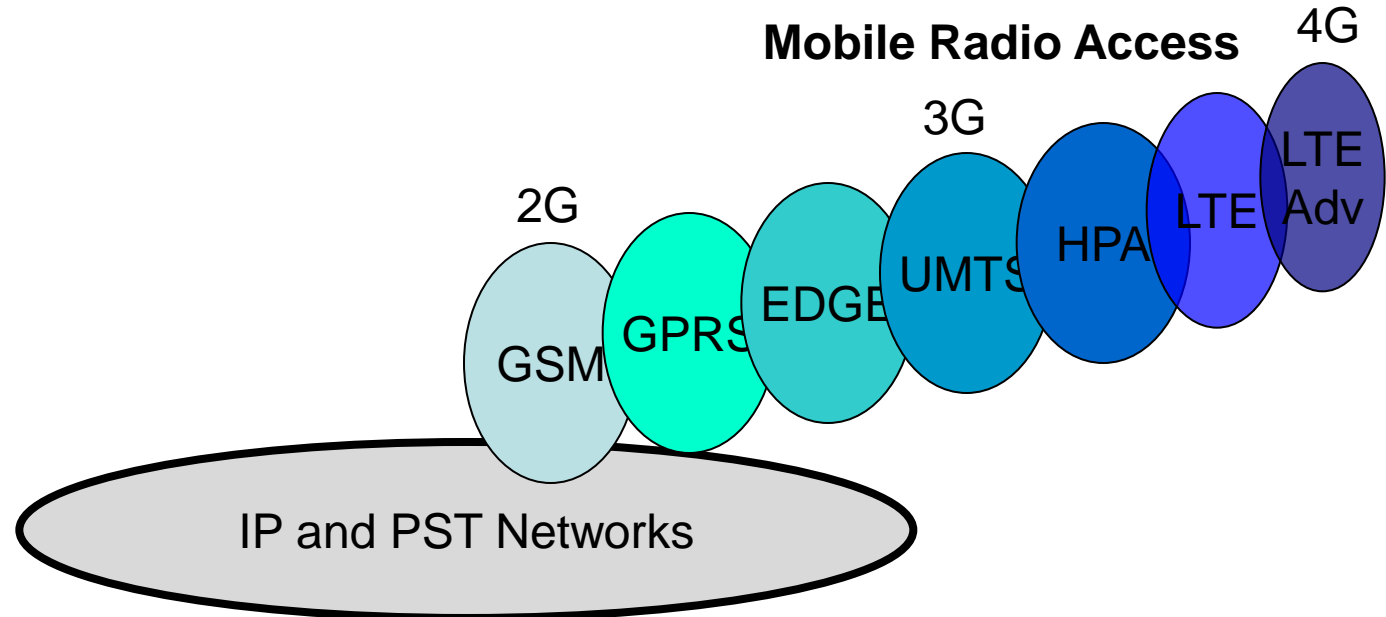
40 years (since when digital era started)

- | | |
|--|------------------------|
| 1. Mobile Radio Access Networks | (Mobile RAN) |
| 2. Local Radio Access Networks | (LAN) |
| 3. Personal Area Networks | (PAN) |
| 4. Wireless Sensor Networks | (WSN) |
| 5. Vehicular / Mobile Radio Ad Hoc Networks | (VANET / MANET) |
| 6. Broadband Radio Access Networks | (BRAN) |
| 7. Body Area Networks | (BAN) |
| 8. The Internet of Things | (IoT, M2M) |

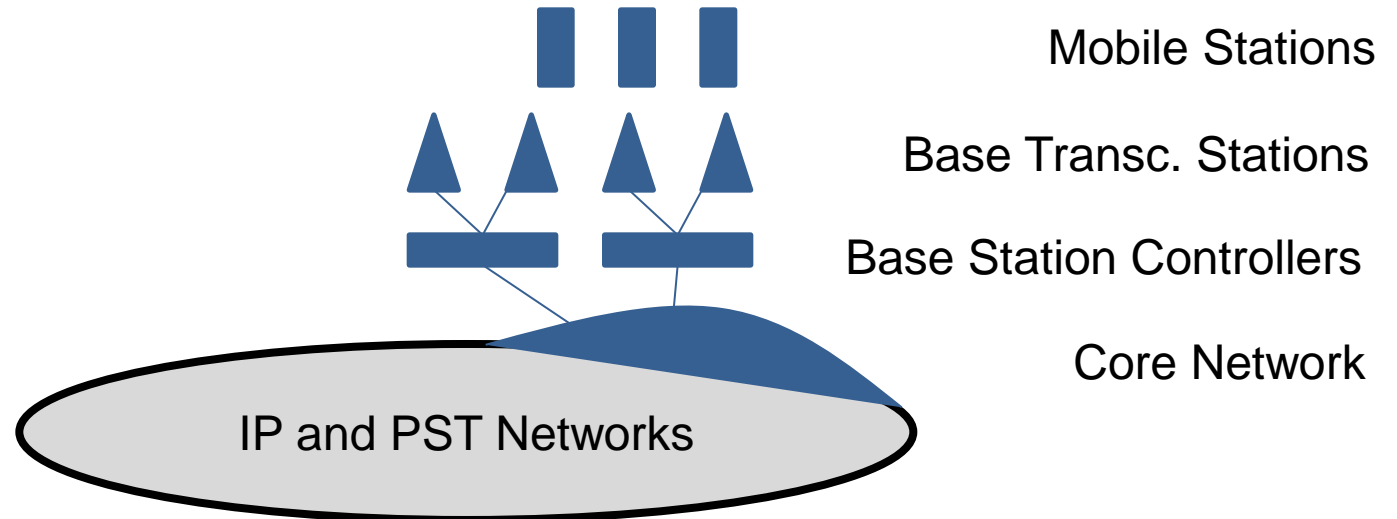
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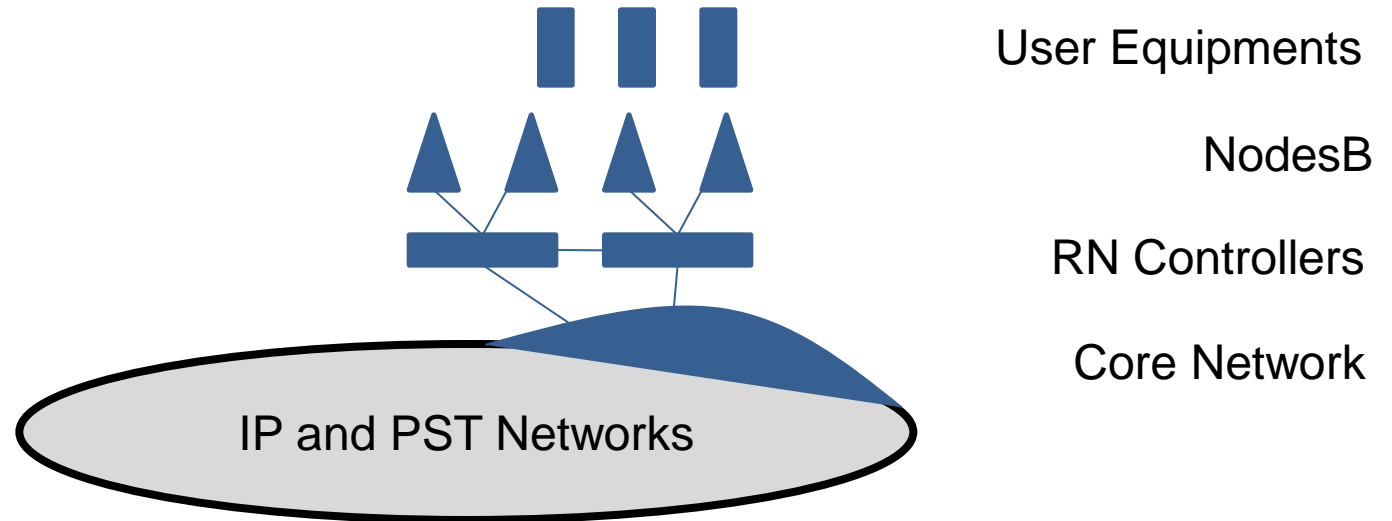
Radio Communication Standards



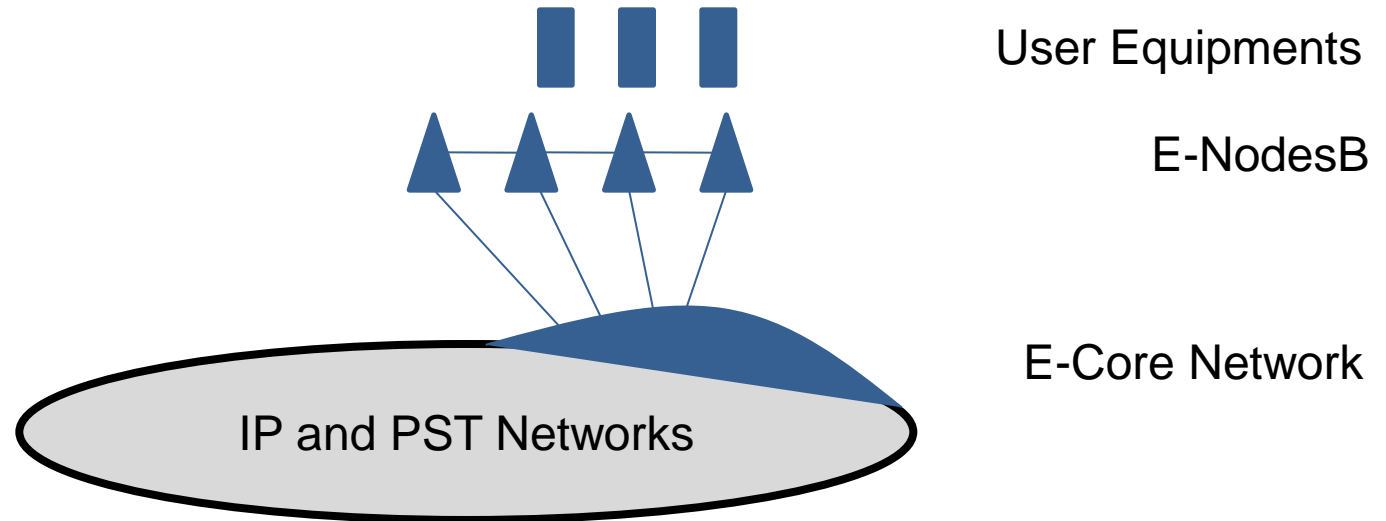
Radio Communication Standards – 2G and GPRS



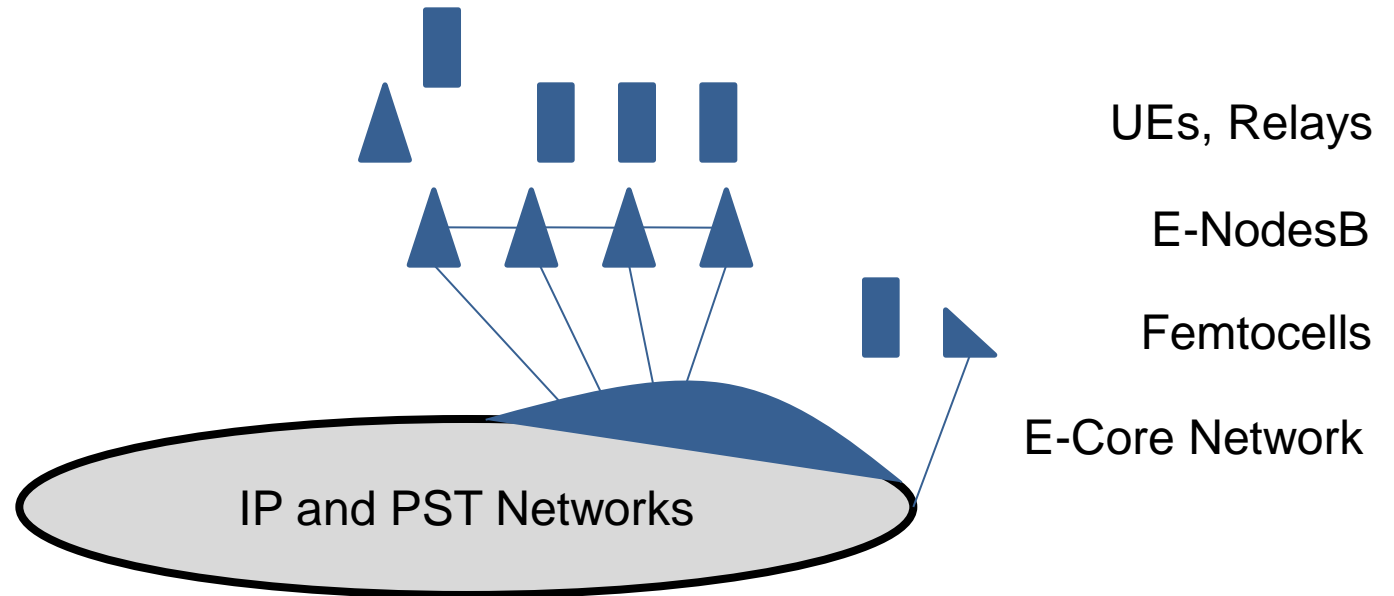
Radio Communication Standards – 3G



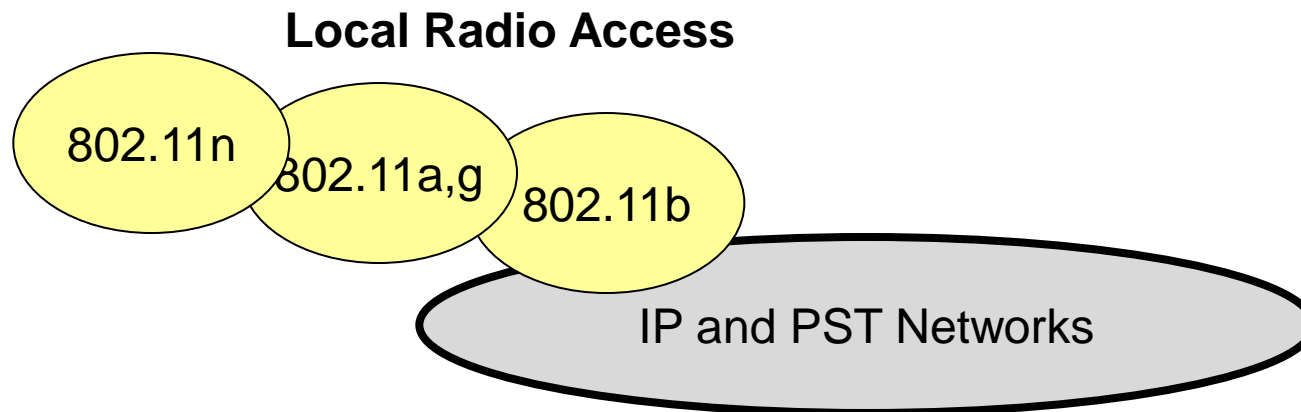
Radio Communication Standards - LTE




Radio Communication Standards – 4G

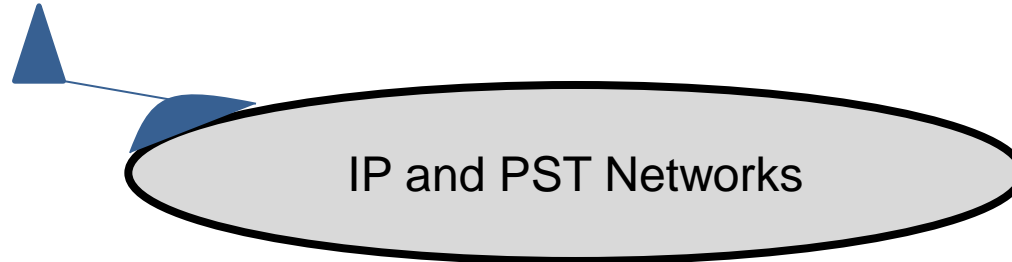


Radio Communication Standards

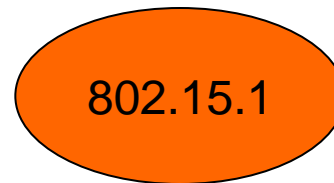


Radio Communication Standards – 802.11b/g/n/...

Wireless
Stations 
Access Point
Gateway/Router



Radio Communication Standards

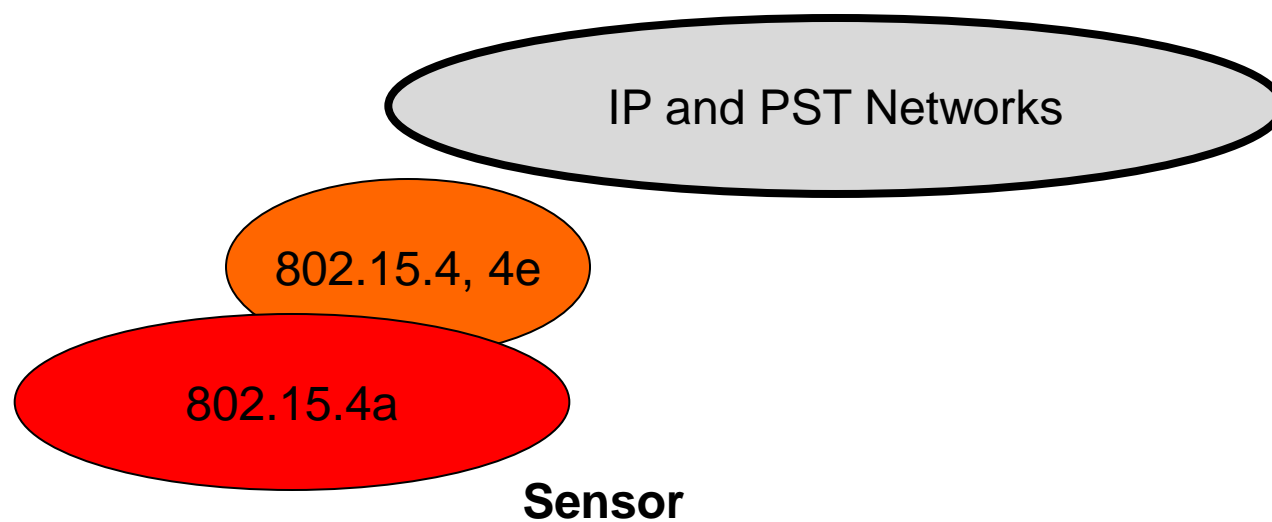


Personal

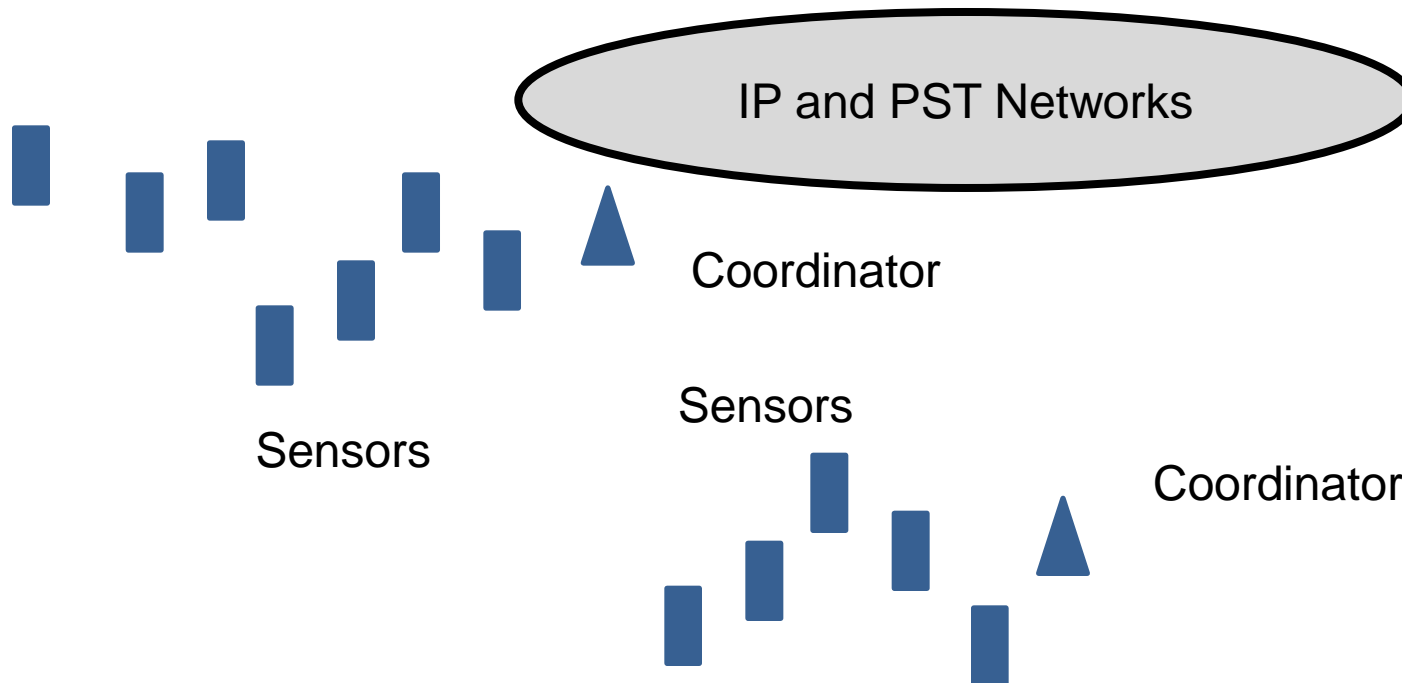
Radio Communication Standards – Bluetooth



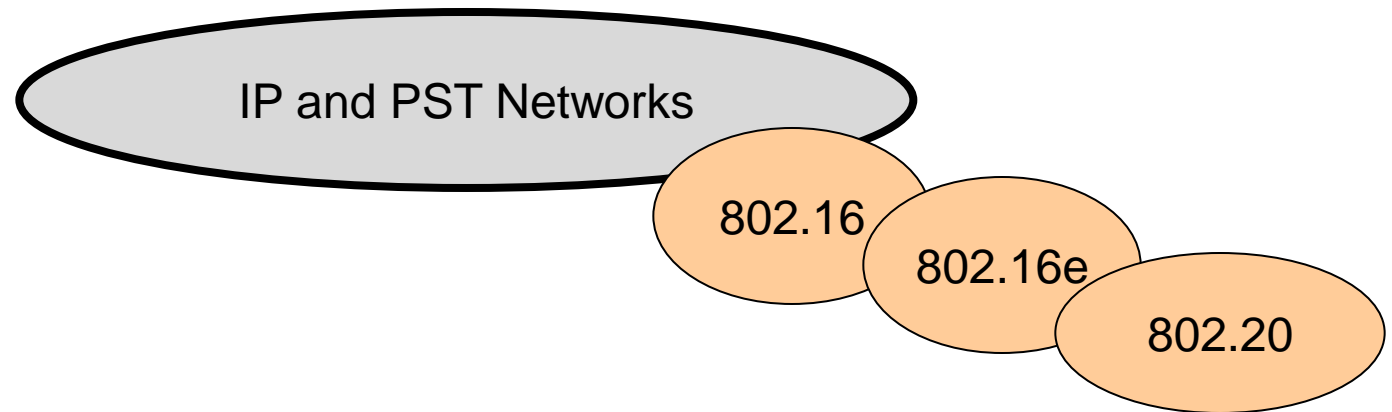
Radio Communication Standards



Radio Communication Standards – 802.15.4

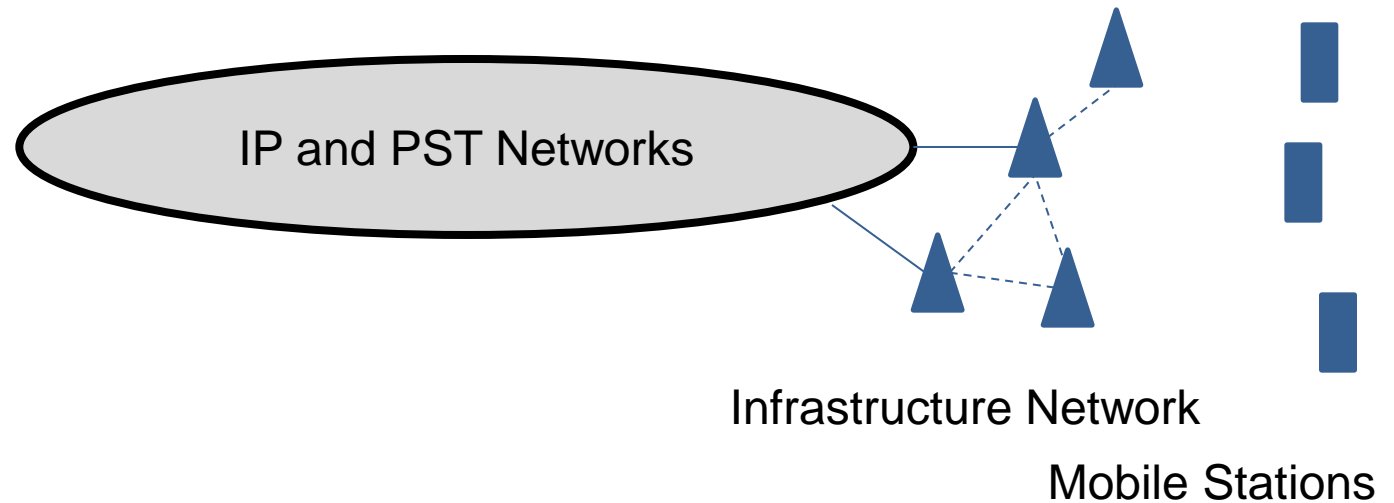


Radio Communication Standards



Broadband Radio Access

Radio Communication Standards – WiMAX



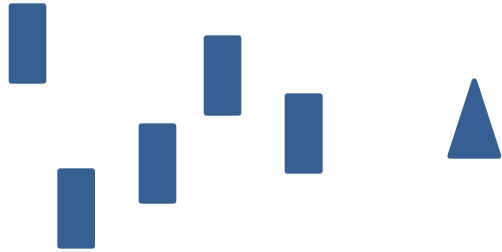
Radio Communication Standards

802.11p

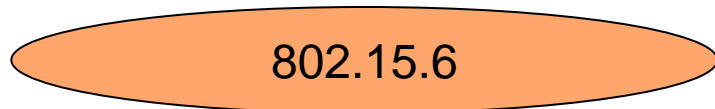
Vehicular Ad Hoc

IP and PST Networks

Radio Communication Standards – WAVE

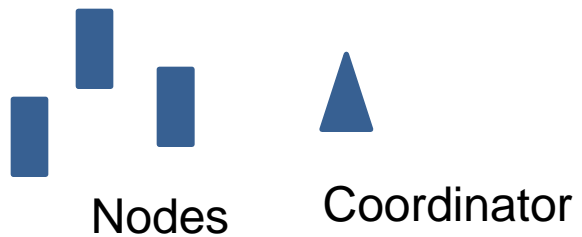


Radio Communication Standards

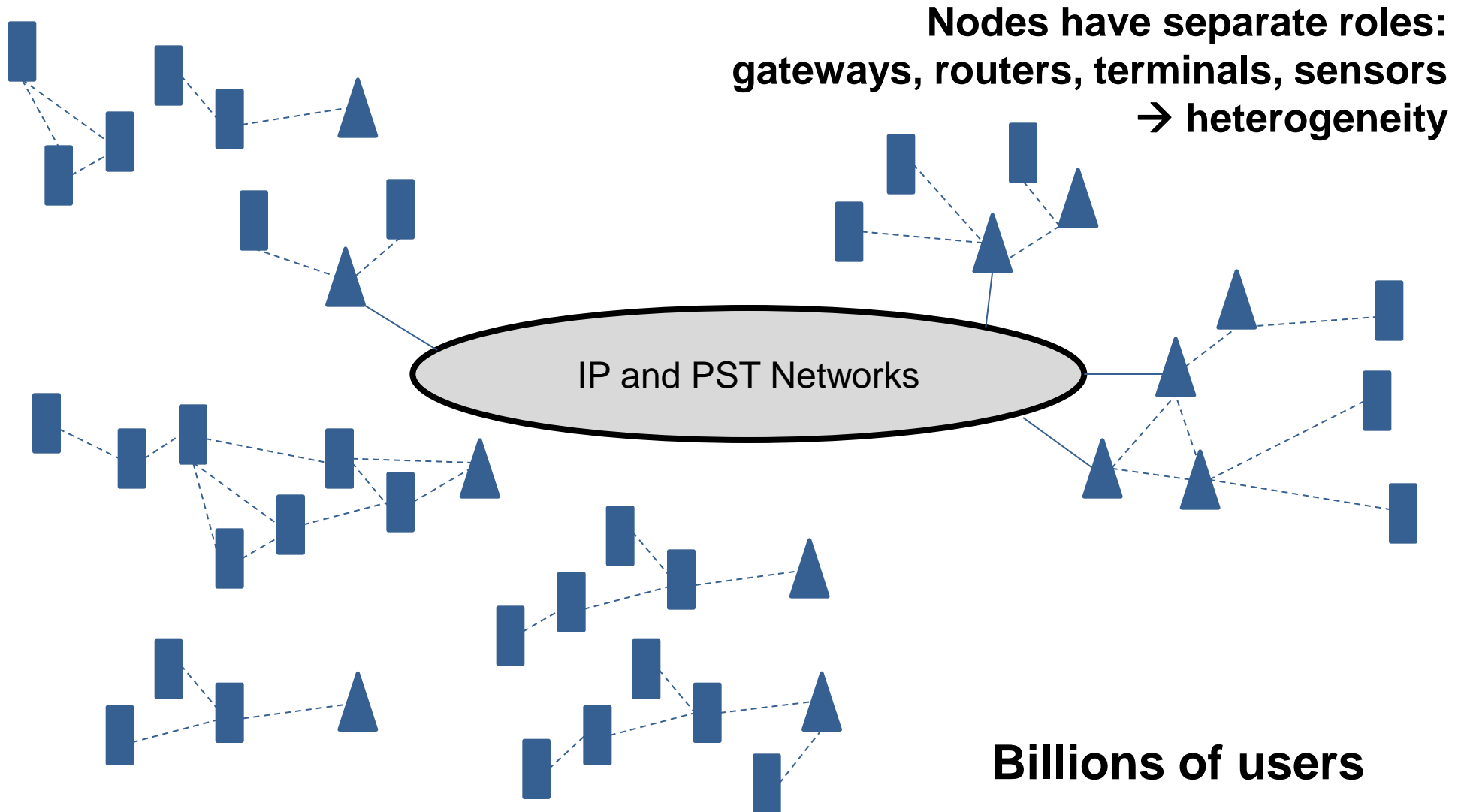


Body

Radio Communication Standards – 802.15.6

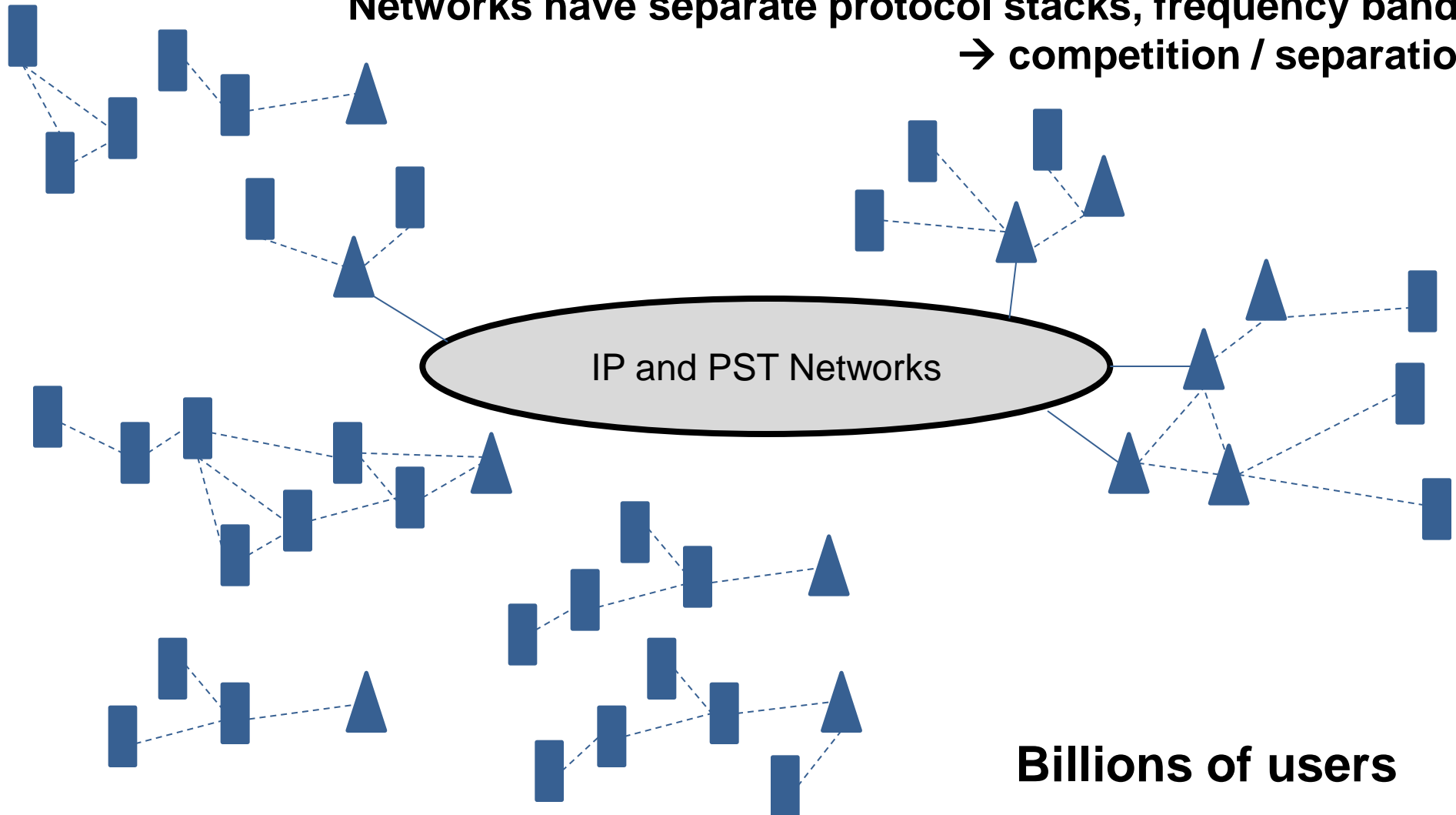


The Whole Picture (as of today)



The Whole Picture (as of today)

Networks have separate protocol stacks, frequency bands
→ competition / separation



Radio Networks Overview

The End
