Regulation and Policy in the Telecommunications Industry TM 612-WS

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Lecture—05
Introduction to Wireless Communication

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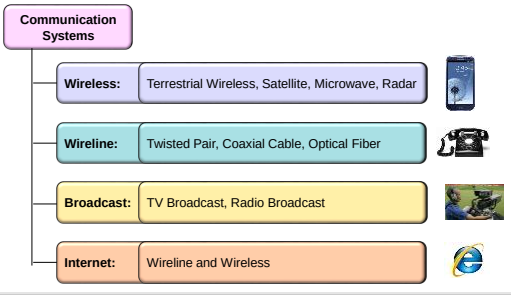
Contents

Types of Communication Systems

Types of Communication Systems

- **A system that conveys information from a source to a destination**



Driving Forces Behind Evolution of Wireless Systems

Driving Forces Behind Evolution

Evolution

1G

5G

7 of 53

Wish List of a Customer

- What are the major wishes of a customer?

Lower Bill

Higher Data Rate

Better user experience (QoS etc.)

More services

8 of 53

Business Goals of a Service Provider

- What are the major business goal of a service provider?
  - More revenue
  - Cost reduction

- What are the Cost Busters?
  - Capital Cost
  - Operation Cost
  - Spectrum

Spectrum

- What is the Major Cost Source?

9 of 53

How to Reduce Cost?

How to reduce cost,
and generate more revenue?

Some Ways to Reduce Cost

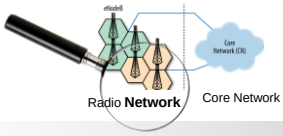
- Reduce Capital Cost
- Reduce Operation Cost
- Use Spectrum efficiently

But How?
Let's see these one by one

How to Reduce Cost?

- Reduce Capital Cost
  - Use less Equipment (e.g. BSs) to serve more users
- Reduce Operation Cost
  - Share the resources (e.g. IP)
- Use Spectrum efficiently
  - Serve More Users in a given spectrum (more simultaneous calls per cell)
  - Send more bits (Send more data per Hz)

Evolution in Radio Network

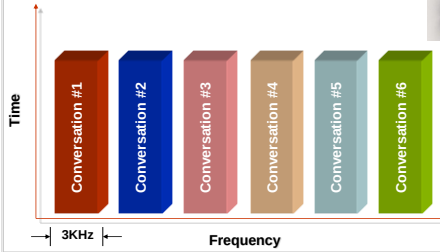


Use Spectrum efficiently

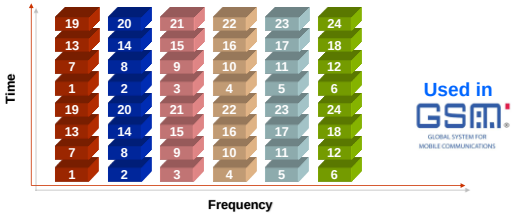
How to Serve More Users in a given SPECTRUM?

- FDMA
- TDMA
- CDMA
- OFDMA

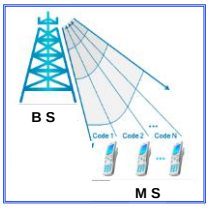
FDMA (1G)

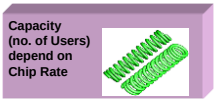


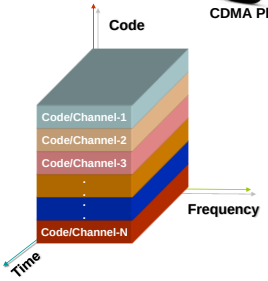
TDMA (2G)



Code Division Multiple Access (CDMA) (3G)







Each user is assigned a unique code which is orthogonal to the codes used by other users

Code Division Multiple Access

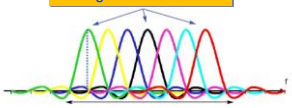
- **Spread spectrum modulation**
  - Originally developed for the military
  - Resists jamming and many kinds of interference
- **All users share same (large) block of spectrum, but different codes**
  - Soft handoffs possible

OFDMA (4G)

Bandwidth is divided into a large number of smaller bandwidths

Called sub-carriers and are typically on the order of 10 kHz

Orthogonal Sub-carriers



Sub-carriers are transmitted simultaneously at different frequencies

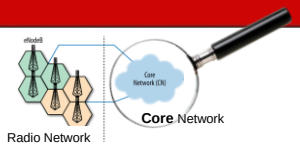
Sub-carriers are mathematically orthogonal

Offers reliability and thus more users can be accomodated

5G

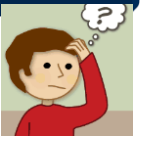
- Will also use OFDMA

Evolution in Core Network



Efficient use of Network Resources

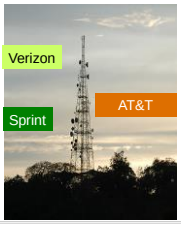
Share the Resources
It would contribute to lower bills
Because it reduces Capital Cost & Operating Cost

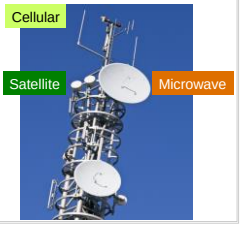


Share the Resources

Several Service Providers share the same Tower (e.g. Sprint, Verizon, & ATT)

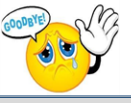
Several Antennas share the same Tower (e.g. Satellite, MW, cellular)





Share the Resources

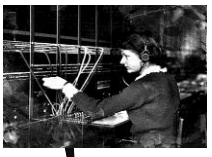
- Use Packet Switching

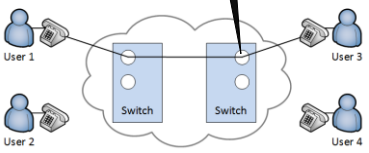


- Circuit Switching

Share the Resources

- Circuit Switching (CS)

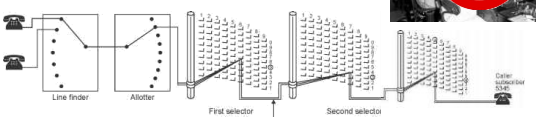


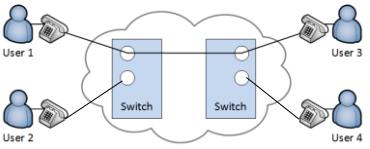


25 of 53

Share the Resources

- Automatic Circuit Switching (CS)

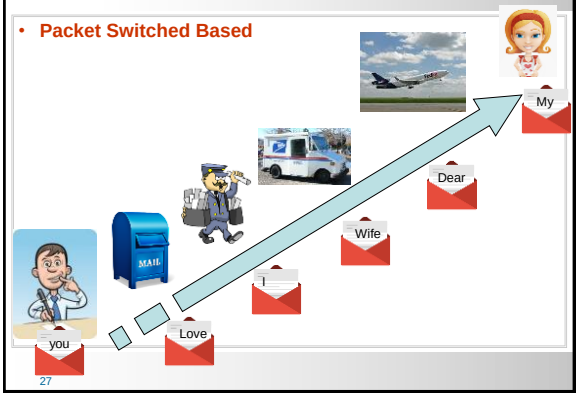




26 of 53

Share the Resources

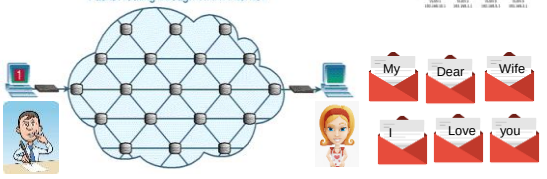
- Packet Switched Based



27

Share the Resources

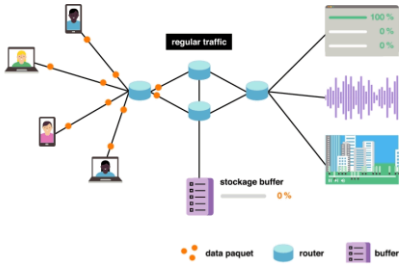
- Packet Switching (PS)
  - Internet Based



28 of 53

Share the Resources

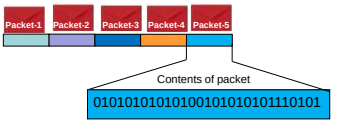
- Packet Switching



29

Packet Switching

- **Packet switching is a digital network transmission system**
- **In this system,**
  - Sender breaks the data into small packets
    - i.e. a sending computer breaks the message/file into small packets
  - The network sends/routes these packets
    - i.e. routers routes these packets in an efficient way
  - The receiver reunite the data packets and reconstruct the message

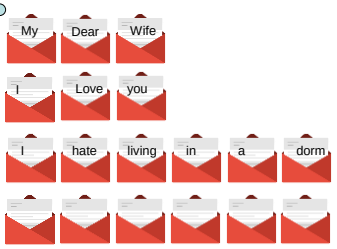


30 of 55

Share the Resources

- **Packet Switching (PS)**

My Dear Wife,
I **LOVE** you.
I **HATE** living in a dorm.
It is difficult to adjust here
I wish if you,
my cute lovely friend
be with me now!!
- - - - - - - - - -
- - - - - - - - - - - -
- - - - - - - - - -



31

Share the Resources

- **PS is delay sensitive, and requires Enhanced QoS**

My Dear Wife,
I **LOVE** you.
I **HATE** living in a dorm.
It is difficult to adjust here
I wish if you,
my cute lovely friend
be with me now!!
- - - - - - - - - -
- - - - - - - - - - - -
- - - - - - - - - -

My Dear Wife,
I **HATE** you.
I **LOVE** living in a dorm
with a cute lovely friend
It is difficult to
adjust with you now
I wish if you were!!!
- - - - - - - - - -
- - - - - - - - - - - -
- - - - - - - - - -

32

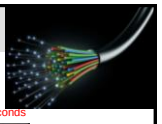
Share the Resources

- **Requires Enhanced QoS, i.e.**
  - Provide different priorities to different data flows to guarantee better performance. i.e.
    - Provide Top priority to **Voice Communication**
    - Second priority to video **Streaming**
    - 3rd priority to **web-browsing**
    - 4th priority to **e-mails**
  - QoS depends on required bit rate, delay, jitter, bit error rate, etc.

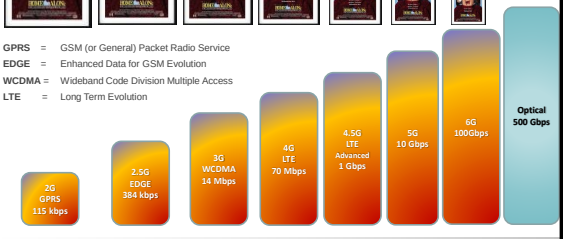
33

Evolution in Services

Higher Data Rates

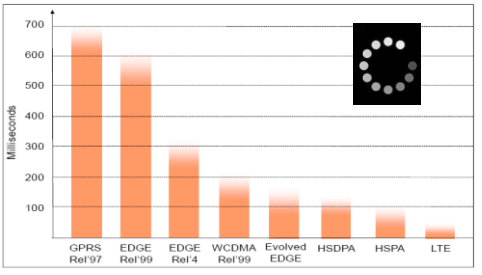


GPRS = GSM (or General) Packet Radio Service
EDGE = Enhanced Data for GSM Evolution
WCDMA = Wideband Code Division Multiple Access
LTE = Long Term Evolution



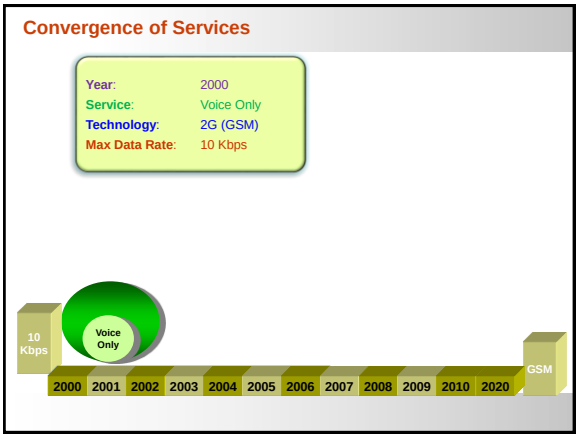
35

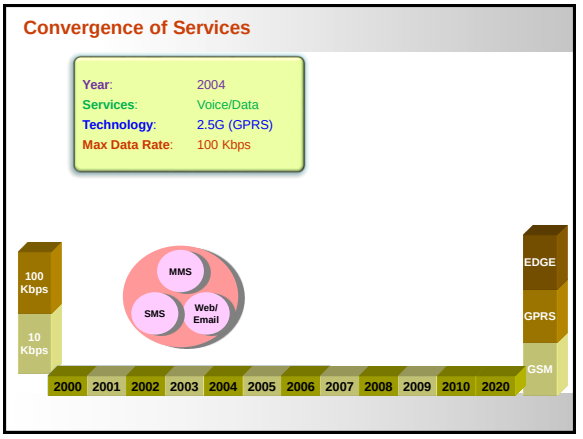
Lower Latencies

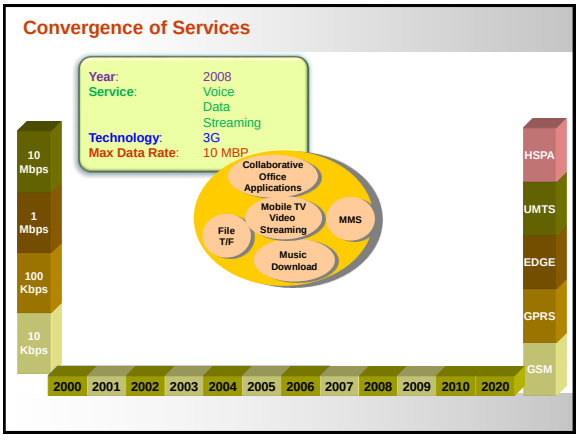


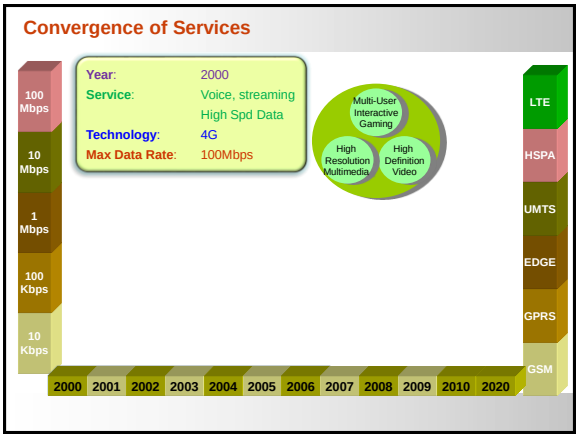
(Latency in commercially deployed technologies)

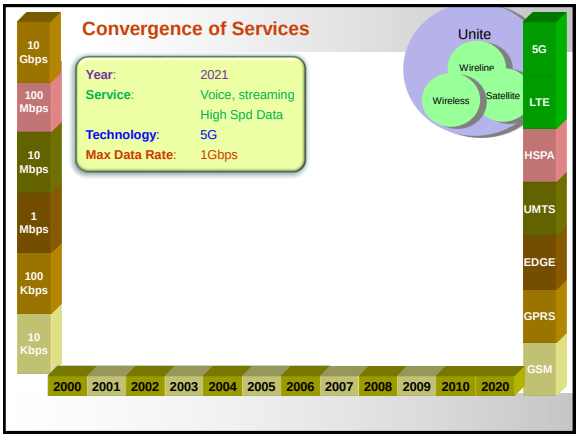
Source 3G Americas

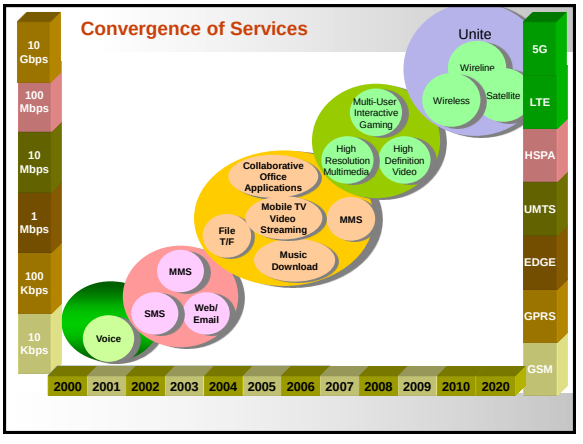

Convergence of Services
Year: 2000
Service: Voice Only
Technology: 2G (GSM)
Max Data Rate: 10 Kbps
10 Kbps
Voice Only
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020
GSM


Convergence of Services
Year: 2004
Services: Voice/Data
Technology: 2.5G (GPRS)
Max Data Rate: 100 Kbps
100 Kbps
10 Kbps
MMS
SMS
Web/ Email
EDGE
GPRS
GSM
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020


Convergence of Services
Year: 2008
Service: Voice
Data
Streaming
Technology: 3G
Max Data Rate: 10 MBP
10 Mbps
1 Mbps
100 Kbps
10 Kbps
Collaborative Office Applications
Mobile TV Video Streaming
MMS
File T/F
Music Download
HSPA
UMTS
EDGE
GPRS
GSM
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020


Convergence of Services
Year: 2000
Service: Voice, streaming
High Spd Data
Technology: 4G
Max Data Rate: 100Mbps
100 Mbps
10 Mbps
1 Mbps
100 Kbps
10 Kbps
Multi-User Interactive Gaming
High Resolution Multimedia
High Definition Video
LTE
HSPA
UMTS
EDGE
GPRS
GSM
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020


Convergence of Services
Year: 2021
Service: Voice, streaming
High Spd Data
Technology: 5G
Max Data Rate: 1Gbps
10 Gbps
100 Mbps
10 Mbps
1 Mbps
100 Kbps
10 Kbps
Unite
Wireline
Wireless
Satellite
5G
LTE
HSPA
UMTS
EDGE
GPRS
GSM
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020


Convergence of Services
10 Gbps
100 Mbps
10 Mbps
1 Mbps
100 Kbps
10 Kbps
Unite
Wireline
Wireless
Satellite
5G
LTE
Multi-User Interactive Gaming
High Resolution Multimedia
High Definition Video
Collaborative Office Applications
Mobile TV Video Streaming
MMS
File T/F
Music Download
MMS
SMS
Web/ Email
Voice
HSPA
UMTS
EDGE
GPRS
GSM
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2020

Wireless Regulations

Wireless Regulations

- **FCC's technical rules govern:**
  - Transmit Power Levels
  - Radio Interference
  - Enablement of Internet of Things Service, either Broadband or Narrowband
  - Provision of roaming service
  - FCC does not implement rules for infrastructure or network sharing
- **FCC rule governing use of wireless frequencies allows that a**
  - A carrier may use 5G frequencies in one area and 4G in other areas

Wireless Regulations

- **FCC's non-technical rules:**
  - Require Carriers that they allow the resale of their services
    - E.g., approval of "T-Mobile — Sprint acquisition" required T-Mobile to provide wholesale services
  - Do not put any limitations/restriction on any 5G licensed wireless provider
  - For national security, banned the use of Huawei and ZTE equipment

HUAWEI ZTE

There is one bonus question

Chapter Review Questions (CRQ)

CRQ# 05

46

CRQ-1

- **A communication System:**

A. Conveys Information from its source to destination

B. Is required to transmits Orthogonal Frequency Multiple Carriers (OFDMA)

C. Is all about spectral efficiently

D. All of above

47 of 55

CRQ-2

- **Multiple Radio Access Technologies used in wireless Networks are:**

A. RATs (Radio Access Technologies) and CATs (Code Access Technologies)

B. FDMA, TDMA, CDMA, OFDMA

C. Multiple Access is not used in Wireless Communication

D. None of above

48 of 55

CRQ-3

- **Pick the most accurate one. QoS is the ability to provide:**
  - A. Different priorities to different data flows to assure good performance
  - B. Top priority to Voice packets
  - C. Least priority to e-mail packets
  - D. All the statements are correct

CRQ-4

- **A method that transmits data in packets over a shared network is called:**
  - A. PS (Packet Switching)
  - B. CS (Circuit Switching)
  - C. SS (Shared Switching)
  - D. AS (Aggregate Switching)

CRQ-5

- **One of the way to reduce operational/Capital cost is:**
  - A. Resources Sharing (e.g. using packet switching)
  - B. CS (Circuit Switching)
  - C. Using more spectrum
  - D. Increasing latency

CRQ-6-Bonus

- **Pick the most accurate statement:**
- **FCC's technical rules in wireless communication**
  - A. Are normally related to the transmit power levels and radio interference
  - B. Are not normally related to the rules for infrastructure or network sharing
  - C. Are normally not related to the transmit power levels and radio interference
  - D. A and B both are correct

Bonus-The total point score remains 10 points

Answers to CRQ

CRQ-1

- **A communication System:**
  - A. Conveys Information from its source to destination
  - B. Is required to transmits Orthogonal Frequency Multiple Carriers (OFDMA)
  - C. Is all about spectral efficiently
  - D. All of above

A: Conveys Information from its source to destination

CRQ-2

- **Multiple Radio Access Technologies used in wireless Networks are:**
  - A. RATs (Radio Access Technologies) and CATs (Code Access Technologies)
  - B. FDMA, TDMA, CDMA, OFDMA
  - C. Multiple Access is not used in Wireless Communication
  - D. None of above

B: FDMA, TDMA, CDMA, OFDMA

CRQ-3

- **Pick the most accurate one. QoS is the ability to provide:**
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D. All the statements are correct

CRQ-4

- **A method that transmits data in packets over a shared network is called:**
  - A. PS (Packet Switching)
  - B. CS (Circuit Switching)
  - C. SS (Shared Switching)
  - D. AS (Aggregate Switching)

A. PS (Packet Switching)

CRQ-5

- **One of the way to reduce operational/Capital cost is:**
  - A. Resources Sharing (e.g. using packet switching)
  - B. CS (Circuit Switching)
  - C. Using more spectrum
  - D. Increasing latency

A. Resources Sharing (e.g. using packet switching)

CRQ-6-Bonus

- **Pick the most accurate statement:**
- **FCC's technical rules in wireless communication**
  - A. Are normally related to the transmit power levels and radio interference
  - B. Are not normally related to the rules for infrastructure or network sharing
  - C. Are normally not related to the transmit power levels and radio interference
  - D. A and B both are correct

Bonus-The total point score remains 10 points

D. A and B both are correct

Home Assignment

Chapter-05

- **Q1.**
  - What are the major driving forces in behind evolution of Radio Communication Networks from 1G to 5G?
- **Q2.**
  - What is Packet switching technology used in 4G/5G communication networks?


Thank
You!