Multimedia communications
ECP 610

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Motivation for the course

why you are taking this class?

Sections ☰ The Washington Post

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The Switch

Google is serious about taking on telecom. Here's why it'll win.

A | 79

By Brian Fung February 6 Follow @b_fung

Larry Page, right, and Sergey Brin, Google's co-founders at the official opening of Google's new European headquarters in Dublin, Ireland, Wednesday, October 6, 2004. Photographer: John Cogill/Bloomberg News.

Google loon

Facebook's internet-providing drones will be as large as JUMBO JETS - and could be in use by 2018

- **Facebook's drones are set to soar at 65,000ft (19,800 metres)**
- **They will provide web access to remote areas of the world**
- **The crafts will be as large as Boeing 747 jet liners, but much lighter**
- **They will be trialled over an unspecified location in the US next year**
- **Drones could be fully operational and deployed within five years**
- **Facebook has joined forces with other tech firms to help develop the planes**

By SARAH GRIFFITHS FOR MAILONLINE

PUBLISHED: 13:55 GMT, 29 September 2014 | **UPDATED:** 14:56 GMT, 29 September 2014

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More than six months since Mark Zuckerberg unveiled plans to connect the world to the web using drones, more details have emerged about how exactly these flying Wi-Fi hotspots will work.

At a summit in New York, Facebook's engineering director announced the vehicles will be closer in size to jumbo jets, than traditional drones, and they'll soar at 65,000ft (19,800 metres).

The firm also announced it will begin testing the drones in an unspecified location above the US as soon as next year


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Quotes updated below

2014 Mobile Data Traffic

Globally, mobile data traffic was 2.5 Exabytes per month in 2014, the equivalent of 631 million DVDs each month or 6,955 million text messages each second.

In 2014, global mobile data traffic grew 1.7-fold, or 69%.

Globally, mobile data traffic in 2014 was equivalent to 28x the volume of global mobile traffic five years earlier (in 2009).

Global mobile data traffic grew 3.2 times faster than global fixed IP traffic in 2014.

Globally, the average mobile-connected end-user device generated 359 megabytes of mobile data traffic per month in 2014, up 61% from 223 megabytes per month in 2013.

Globally, the average smartphone generated 819 megabytes of mobile data traffic per month in 2014, up from 563 megabytes per month in 2013.

Globally, the average laptop generated 2,641 megabytes of mobile data traffic per month in 2014, up from 2,238 megabytes per month in 2013.

Globally, the average tablet generated 2,076 megabytes of mobile data traffic per month in 2014, up from 1,261 megabytes per month in 2013.

2019 Mobile Data Traffic

Globally, mobile data traffic will grow 10-fold from 2014 to 2019, a compound annual growth rate of 57%.

Globally, mobile data traffic will reach 24.3 Exabytes per month by 2019 (the equivalent of 6,079 million DVDs each month), up from 2.5 Exabytes per month in 2014.

Globally, mobile data traffic will reach an annual run rate of 291.8 Exabytes by 2019, up from 30.3 Exabytes in 2014.

Global mobile data traffic will grow 3 times faster than global fixed IP traffic from 2014 to 2019.

Globally, mobile data traffic will account for 15% of global fixed and mobile data traffic by 2019, up from 4% in 2014.

Globally, mobile data traffic by 2019 will be equivalent to 266x the volume of global mobile traffic ten years earlier (in 2009).

Globally, 54% of mobile connections will be 'smart' connections by 2019, up from 26% in 2014.

Globally, 59% of mobile connections (excluding LPWA) will be 'smart' connections by 2019, up from 26% in 2014.

Globally, 97% of mobile data traffic will be 'smart' traffic by 2019, up from 88% in 2014.

Globally, mobile traffic per mobile-connected end-user device will reach 2,807 megabytes per month by 2019, up from 359 megabytes per month in 2014, a CAGR of 51%.

Globally, mobile traffic per mobile connection (including M2M/LPWA) will reach 2,120 megabytes per month by 2019, up from 339 megabytes per month in 2014, a CAGR of 44%.

Video Highlights

It would take an individual over 5 million years to watch the amount of video that will cross global IP networks each month in2018. Every second, nearly a million minutes of video content will cross the network by2018.

Globally, IP video traffic will be 79 percent of all consumer Internet traffic in 2018, up from66 percent in 2013. This percentage does not include video exchanged through peer-to-peer (P2P) filesharing. The sum of all forms of video (TV, video on demand [VoD], Internet, and P2P) will be in the range of80to 90 percent ofglobal consumer traffic by 2018.

Internet video to TV doubled in 2013. Internet video to TV will continue to grow at a rapid pace, increasing fourfold by 2018. Internet video to TV traffic will be 14 percent of consumer Internet video traffic by 2018, up from11percent in 2013.

Consumer VoD traffic will double by 2018. The amount of VoD traffic by 2018 will be equivalent to 6billion DVDs per month.

Content delivery network traffic will deliver over half of all internet video traffic by 2018. By 2018, 67percent of all Internet video traffic will cross content delivery networks, up from 53 percent in 2013.

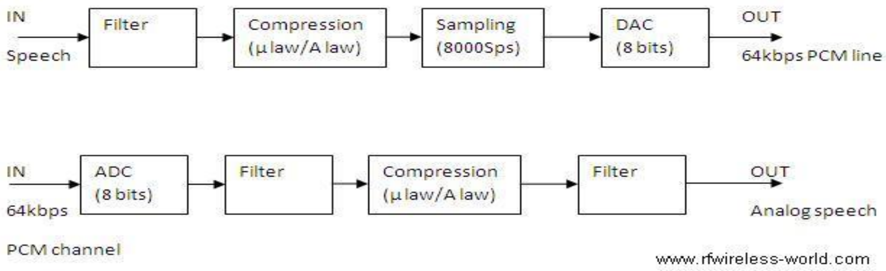
Table 10. Global Consumer Internet Traffic, 2013–2018

Consumer Internet Traffic, 2013–2018							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**CAGR 2013–2018**
By Network (PB per Month)							
Fixed	27,882	33,782	40,640	48,861	58,703	70,070	20%
Mobile	1,189	2,102	3,563	5,774	8,968	13,228	62%
By Subsegment (PB per Month)							
Internet video	17,455	22,600	29,210	37,783	48,900	62,972	29%
Web, email, and data	5,505	6,706	8,150	9,913	11,827	13,430	20%
File sharing	6,085	6,548	6,803	6,875	6,856	6,784	2%
Online gaming	26	30	41	64	88	113	34%

Motivation

- Multimedia: content that uses a combination of content formats:
  - Video
  - Audio
  - Speech
  - Text
  - Animations
  - Images
  - …

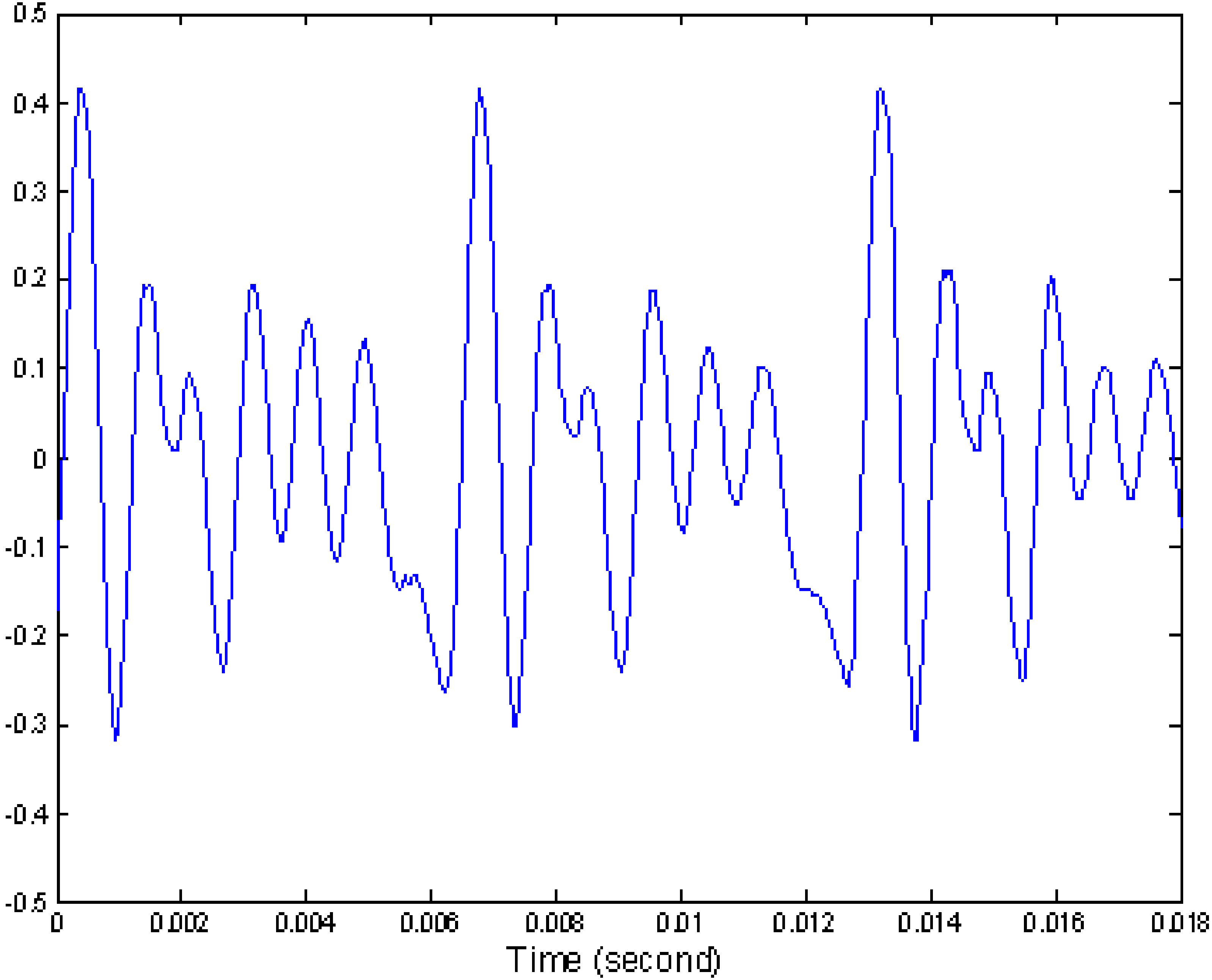
Is it a new topic?



- Speech signals in PSTN
  - Use of speech features
  - Need to understand the speec
  - Sampling rate, encoding, .. Etc
- Speech in GSM
  - GSM speech CODEC (13kbps : full rate)
- That was "multimedia communications" in its simplest form!

Differences

- Speech/audio/Image/video
  - Can tolerate errors
  - Quality depends on human perception
  - Can have strict deadlines
  - Have some sort of " time correlation" for speech
  - Have some sort of "spatial correlation" for images
  - Have sort of "time AND spatial correlations" for video


0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
Time (second)

Multimedia communications

- Communications over what?
  - Circuit switched network (ISDN)
  - IP network
  - Wireless network
    - Mobile network (3G-LTE)
    - WiFi networks

Multimedia communications

- Different requirements for different applications
  - Delay sensitive applications
    - VoIP
    - Video chatting
    - Remote education
  - Delay sensitive, but less sensitive ☺
    - Video streaming
    - Music streaming (sound cloud)
  - Delay sensitive, but less and less sensitive
    - TV broadcasting

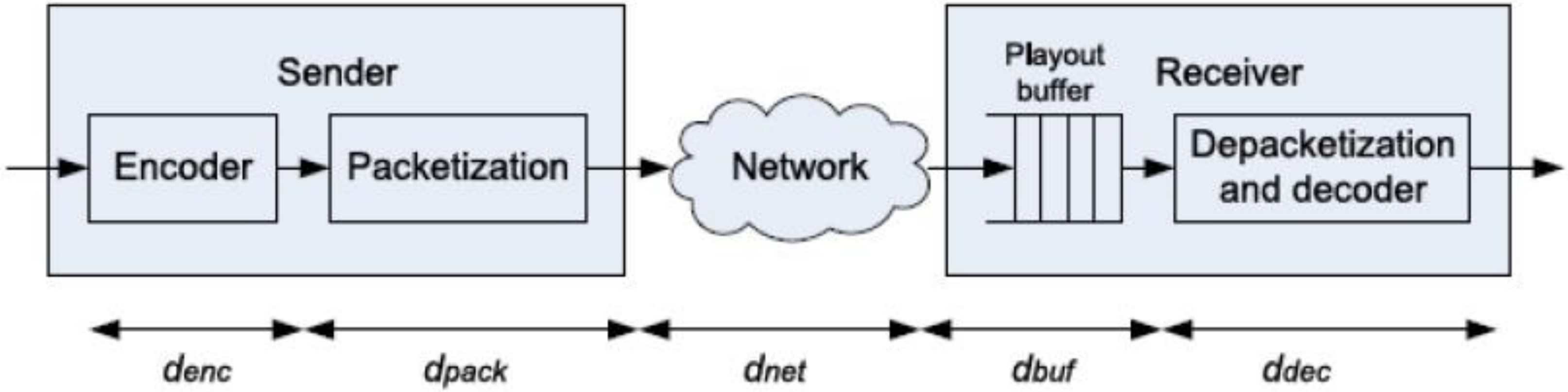
Different requirements for different applications

- Delay sensitive, really sensitive!
  - Telemedicine
    - Remote surgeries
    - Remote healthcare
  - Distributed gaming
  - Augmented reality
  - Surveillance

Different requirements …

- Data rates
- Error tolerance
- Receiver complexity
- Tolerance for BW fluctuations
- Heterogeneity of receivers
  - Tablets
  - Smart phones
  - Large displays
  - …

Multimedia communications



The total end-to-end delay

$$D = d_{enc} + d_{pack} + d_{net} + d_{buf} + d_{dec},$$

where d_{enc} is the encoding delay, d_{pack} is the packetization delay, d_{net} is the delay introduced by the network, d_{buf} is the buffering delay, and d_{dec} is the decoding delay

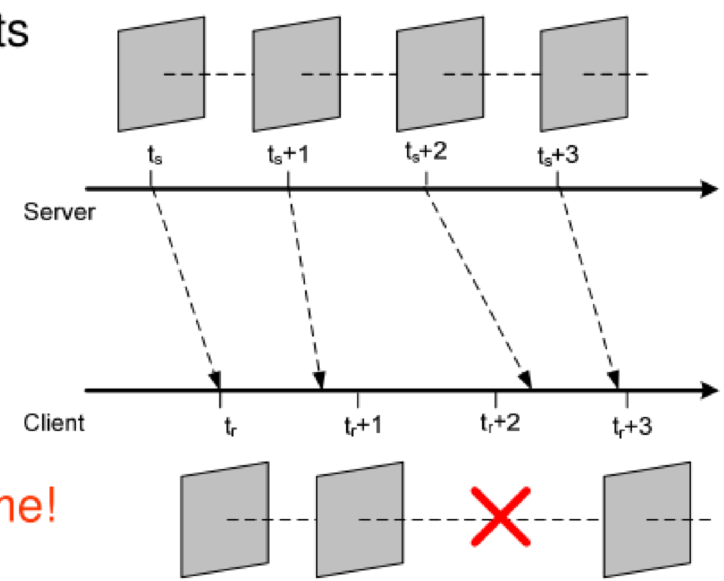
Major challenges

- Multimedia signals at the receiver should satisfy some QoS constraints
  - However, it is transmitted over the Internet, which generally does not guarantee QoS
  - TCP versus UDP
- What happens when an error occurs?
  - Can we do something better than ignoring the frames?
- Is the order of packets important?

Multimedia Delivery over the Internet/wireless networks: Multimedia Streaming

- Partition video bitstream into packets, deliver packets
- Start delivery, begin playback while video bitstream is still being downloaded (5-15 sec delay)
- *Simultaneous delivery and playback* (with short delay)
- Advantages:
  - Low delay before viewing
  - Minimum storage requirements
  - Increased flexibility

Examples?



SOFT real-time!

Major challenges

- What about stored multimedia?
  - Locally stored
    - DVDs, blue ray
  - Remotely stored
    - Youtube, netflix
    - Compression?
    - Different receivers!
    - Transmission?

Data center locations

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Welcome

Working here

Community outreach

Hamina, Finland

Cooling with sea water

We use an innovative sea water cooling system at our data center in Hamina.

Watch the video

From paper mill to data center

In March 2009, we purchased the Summa Mill from Finnish paper company Stora Enso and outlined our plans to convert the 60 year old paper mill into a data center. After investing an initial €200 million, we completed the first phase of the project in September 2011. More than 2,000 individuals working for 50 companies (mostly Finnish and from the local area) contributed to the project.

Who do I contact for more information?

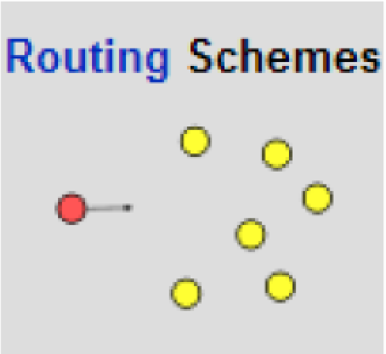
For community-related inquiries, email googlehaminadc@google.com. If you are a member of the media, please contact press@google.com.

For more answers to our most frequently asked

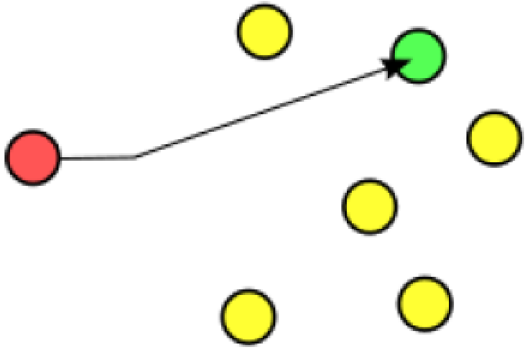
Major challenges

- Available bandwidth is dynamic
  - Cannot reserve BW in most wireless/Internet connections
  - What is the solution?
    - Faster than the available BW?
    - Slower than the available BW?

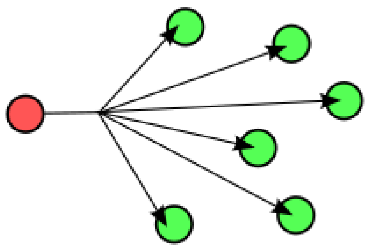
21 **Media Communication – Routing schemes**
Unicast, Multicast, Broadcast



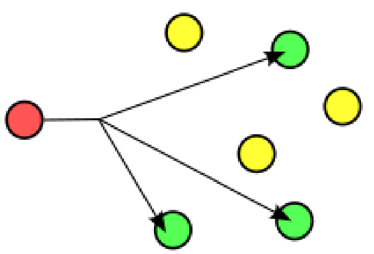
- *Point-to-point (Unicast)*
  - One-to-one
  - Properties depend on *available back channel*:
    - With back channel: Receiver can provide feedback to sender => sender can adapt processing
    - Without back channel: Sender has limited knowledge about the channel
  - Examples: Videophone, unicast over the Internet



Media Communication - Network characteristics
Unicast, Multicast, Broadcast



- *Broadcast*
  - One-to-many (basically one-to-all)
  - Typically different channel characteristics for each recipient
  - Sometimes, system is designed for worst case-channel
  - Example: Broadcast television



- *Multicast*
  - One-to-many (but not everyone)
  - Example: IP-Multicast over the Internet
  - More efficient than multiple unicasts

Why is classification of network solutions (Unicast, Multicast, Broadcast) essential for media communications?

Why attend a video communications class?

Answer 3a: Active and challenging research area

- **Where can you publish?**
  - IEEE Trans. on Multimedia
  - IEEE Journal Selected Areas of Communication
  - IEEE Trans. on Mobile Computing
  - IEEE Trans. on Circuits and Systems for Video Technology
  - IEEE Trans. on Wireless Communications
  - IEEE Trans. on Signal Processing (and Signal Proc. Letters)
  - IEEE Trans. on Vehicular Technology
  - IEEE Trans. on Networking
  - IEEE Trans. on Image Processing
  - …
  - IEEE GLOBECOM
  - IEEE ICIP
  - IEEE ICASSP
  - IEEE INFOCOM
  - IEEE MMSP
  - IEEE ICME
  - ACM Multimedia
  - Packet Video
  - Even systems conferences, e.g. DAC
  - …

What will you learn in this course?

- Multimedia signals representations
  - Speech, audio, images, video
- Lossless compression techniques
- Speech compression and quality of service
- Image and video compression
- Video error resilience and concealment
- Network protocols for video transmission
- Signaling (SIP)
- IP multimedia subsystem

Tools to be used

- MATLAB
- OPNET
- C++
  - Will give you part of the code, you complete it
- others

Assignment (1)

- Write a report about your previous experiences related to multimedia communications in your company, and your company's approach to deal with the explosion happening in data usage for multimedia applications. How it will handle the high QoS requirements (delay, data rates, .. Etc)?

- Deadline: Sunday Feb 15^{th}.