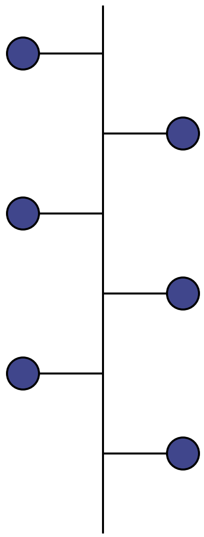
Introduction to Communication Networks and Distributed Systems



Unit 13: Wireless/Mobile Communication Multimedia

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Wireless/Mobile Communication Multimedia

- Diversity of communication requirements:
  - Voice, Radio/TV distribution, Data, Video
  - E-Commerce, Entertainment, Measurement/control data..

- Wireless dominates last hop
  - Because cable is always a constraint...

- Diversity of radio technologies will remain ...
  - Pico-cell – O(10m) $\Rightarrow$ covers a room
  - Micro-cell – O(100m) $\Rightarrow$ covers a floor/street
  - Macro-cell – O(10 km) $\Rightarrow$ Covers an neighborhood, big antennas strategically placed
  - Satellites (regions/countries)

Wireless, Nomadic, Mobile

- Wireless (cordless)
  - Just replace the cable (distance between the Mobile Handheld (MH) and Access Point (AP) might be different)

  $\Rightarrow$ No change of AP at all

- Nomadic
  - MH may use different APs

  $\Rightarrow$ No change of AP while communicating!

- True Mobile
  - MH changes APs while communicating

  $\Rightarrow$ Continuity of data streams not necessary, but Continuity of services

- Roaming
  - Changing of the area and the provider

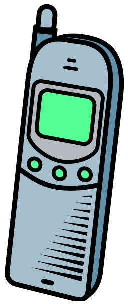
Mobile devices (with limited power!!)

Pager
- receive only
- tiny displays
- simple text messages

SmartPhone
- Multi touch displays
- Simple applications
- Full network access

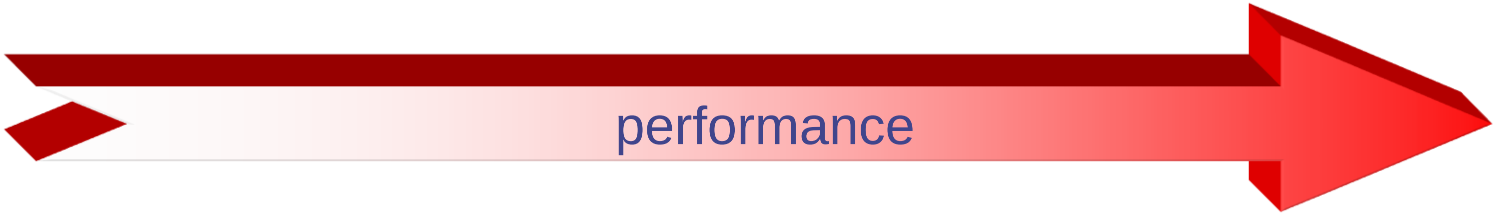
Laptop
- fully functional
- standard applications

Sensors, embedded controllers



Mobile phones
- voice, data
- simple graphical displays

Netbook
- tiny keyboard
- Smaller screen



Multimedia?

- Humans communicate using senses..
  - Ears, Eyes, Nose, Touch…
- How can we support more than data?
  - Voice …
  - Video …
- We have to
  - Get them digital …
  - Transmit them (quality, quality!)
  - Play them (timely!)

A few words about audio compression [Kurose]

- Analog signal sampled at constant rate
  - Telephone: 8,000 samples/sec
  - CD music: 44,100 samples/sec
- Each sample quantized, i.e., rounded
  - e.g., 256 possible quantized values
- Each quantized value represented by bits
  - 8 bits for 256 values

- Example
  - 8,000 samples/sec, 256 quantized values $\Rightarrow$ 64,000 bps
- Receiver converts bits back to analog signal

  $\Rightarrow$some quality reduction
- Example rates
  - CD: 1.411 Mbps
  - MP3: 96, 128, 160 kbps
  - Internet telephony: 5.3 kbps and up

A few words about video compression [Kurose]

- Video
  - sequence of images displayed at constant rate, e.g. 24 images/sec
- Digital image
  - array of pixels, each pixel represented by bits
- Redundancy
  - spatial (within image)
  - temporal (from one image to next)
- Examples
  - MPEG 1 (CD-ROM) 1.5 Mbps
  - MPEG2 (DVD) 3-6 Mbps
  - MPEG4 (often used in Internet, < 1 Mbps)
- Research
  - layered (scalable) video
  - adapt layers to available bandwidth

MM Networking Applications

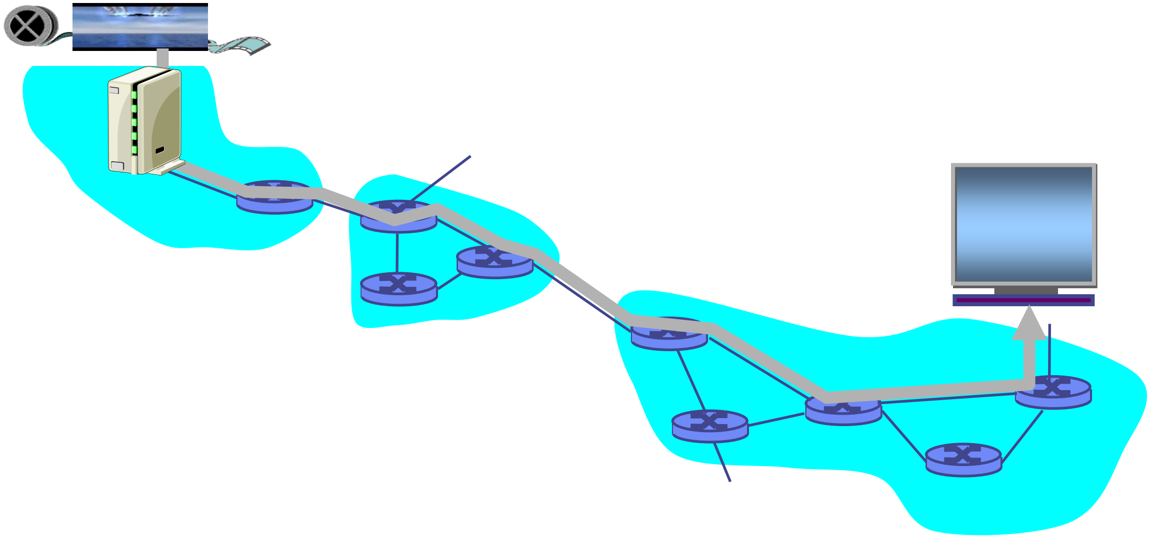
[Kurose]

- Classes of MM applications
  1) stored streaming
  2) live streaming
  3) interactive, real-time

- Fundamental characteristics
  - Typically delay sensitive (end-to-end delay / delay jitter)
  - Loss tolerant: infrequent losses cause minor glitches
  - Antithesis of data, which are loss intolerant but delay tolerant

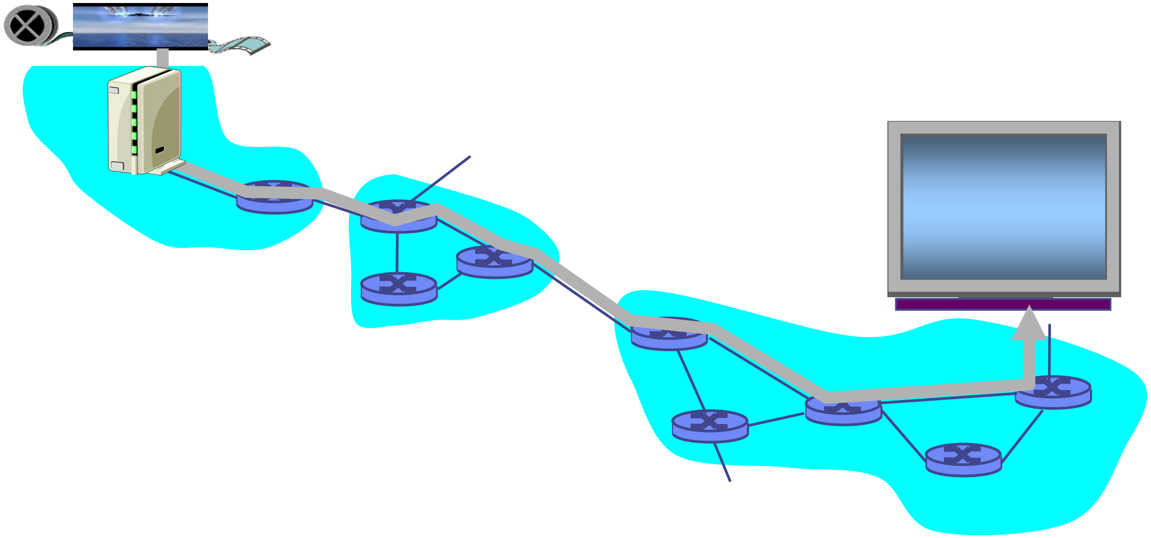
Jitter is the variability
of packet delays within
the same packet stream

Streaming Stored Multimedia



- Stored streaming
  - media stored at source, transmitted to client
- Streaming
  - client playout begins before all data has arrived
- Timing constraint for still-to-be transmitted data
  - ⇒in time for playout

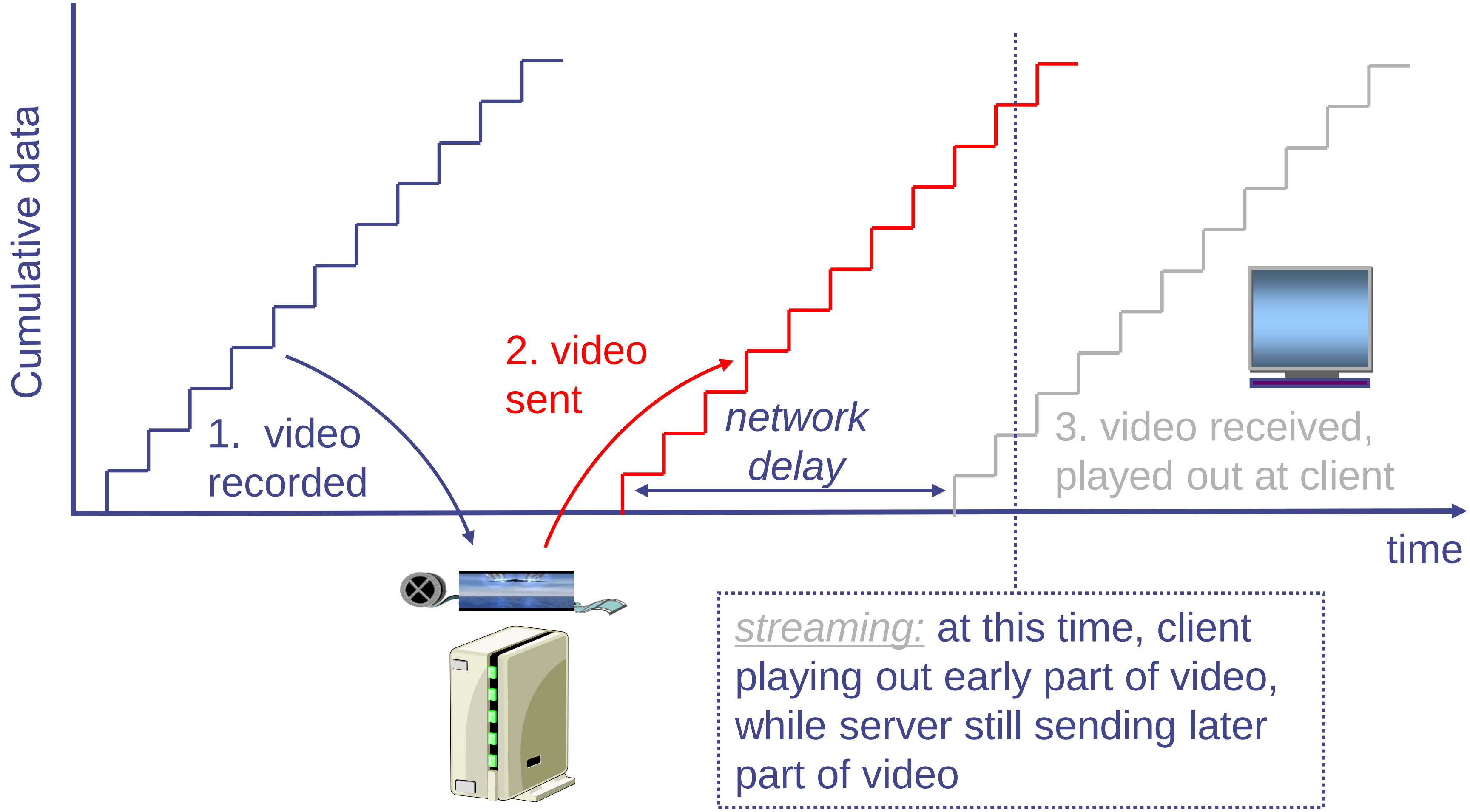
Streaming Stored Multimedia: Interactivity [Kurose]



- VCR-like functionality
  - client can pause, rewind, FF, push slider bar
  - 10 sec initial delay OK, 1-2 sec until command effect OK
- Timing constraint for still-to-be transmitted data

  ⇒in time for playout

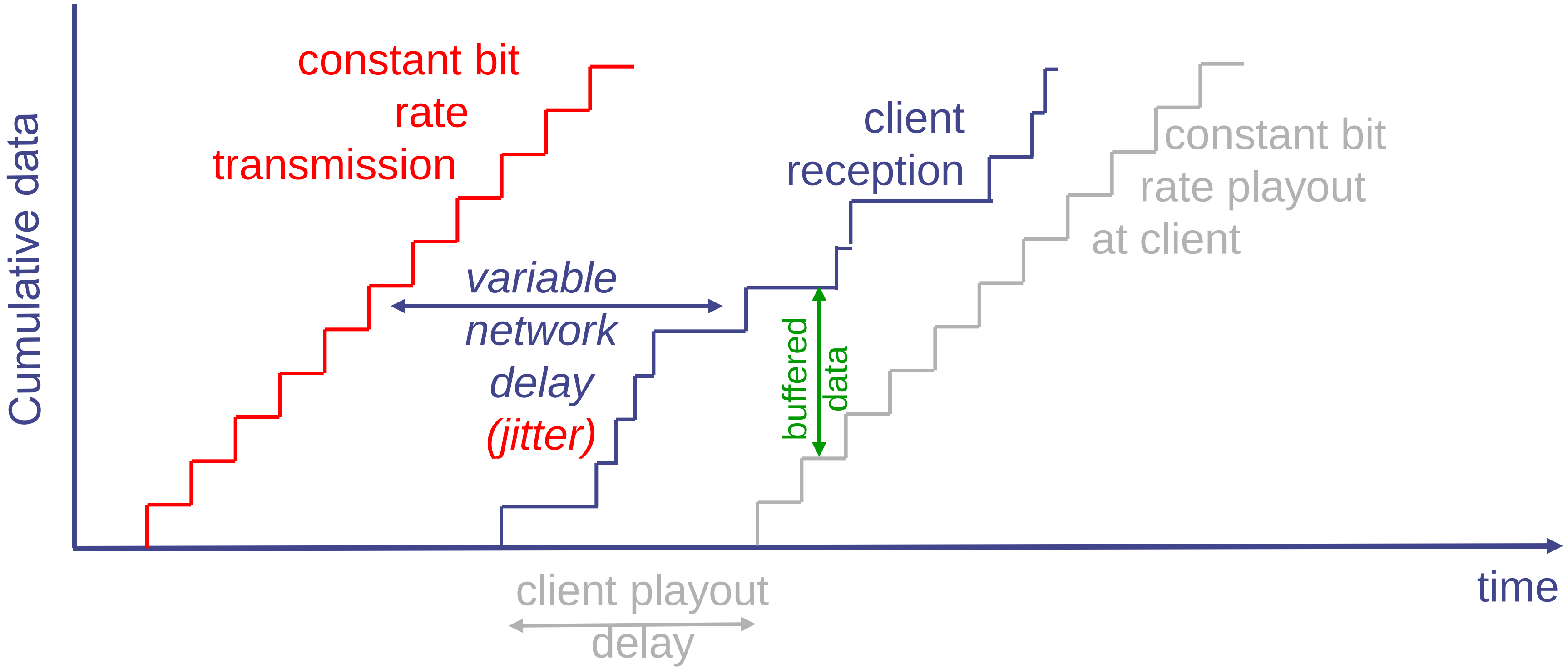
Streaming Stored Multimedia: IDEA [Kurose]



streaming: at this time, client playing out early part of video, while server still sending later part of video

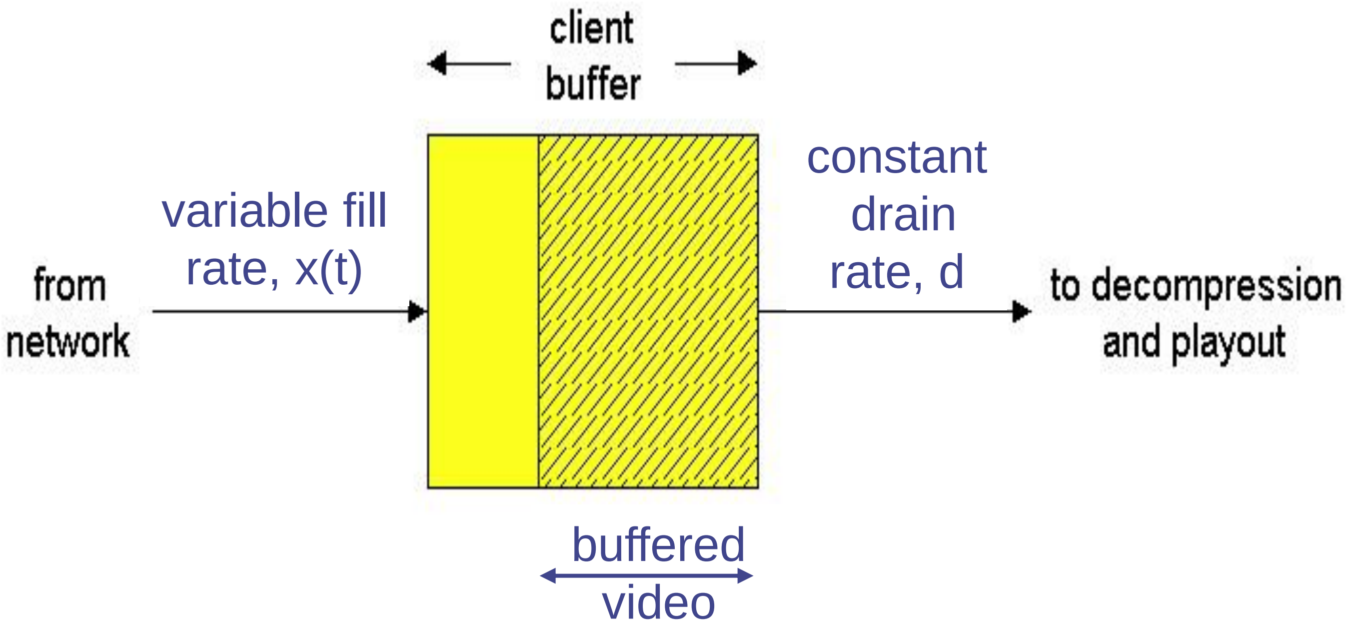
Reality over Internet: Delay Jitter [Kurose]

- Consider the end-to-end delays of two consecutive packets: difference can be more



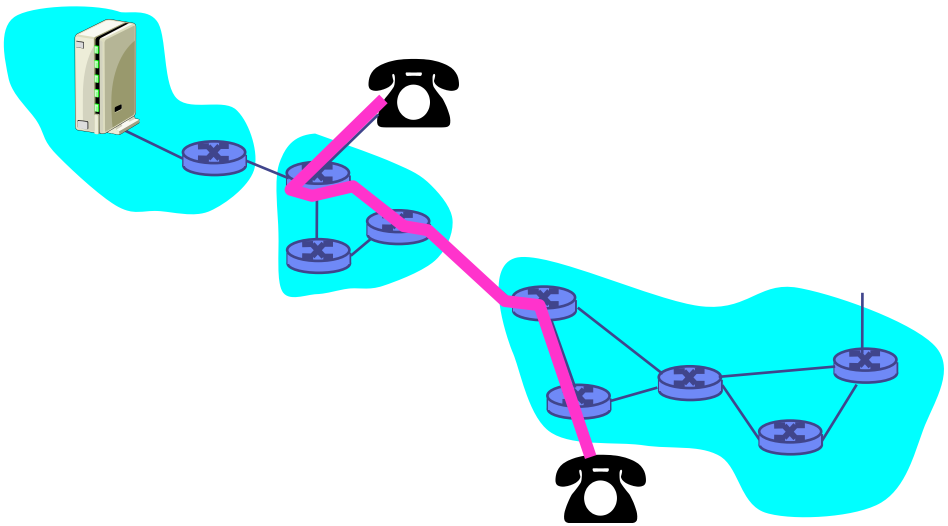
Streaming Multimedia: Client Buffering

- Client-side buffering, playout delay compensate for network-added delay, delay jitter



Real-Time Interactive Multimedia

[Kurose]



- Applications
  - IP telephony, video conference, distributed interactive worlds
- End-end delay requirements
  - audio: < 150 msec good, < 400 msec OK
    - includes application-level (packetization) and network delays
    - higher delays noticeable, impair interactivity
- Session initialization
  - how does callee advertise its IP address, port number, encoding algorithms?

What can we do about the variability of delay/losses ?

- Why do we have varying delay?
  - Because of varying load...
  - Remember: Circuit switches had fixed resources assigned to a (presumably) fixed traffic!

- Over-provisioning: Just have enough resources
  - motivation: low load factor r $\Rightarrow$ low queuing delay
  - Reservation of resources per flow,...
  - Adoption of additional flows (Admission Control, remember: Busy signal on phone lines)
  - How much load comes from a flow (policing)
  - Take care in which sequence packets will be forwarded (scheduling) – some packets might even be dropped!

Some fundamental features of the communication

- Communications has always been focused just on information TRANSPORT

- Over ages there has been no information storage and information processing beyond that organized by humans…

- One “dream of perfect communication”
  - Imagine your “corresponding partner” is close.
  - Select the most proper way of inter-human interaction
  - Capture this – and make it available remotely.
  - Still missing e.g. touch (haptic), smell, taste

In the past: Processing = coding + switching

Today: end-to-end media transport

- Content is melted with media
  - Media - text, images, voice, and video streams - is transported from source or storage device to some presentation or storage device

- Humans use the source and presentation devices (such as phone, TV set, computer) as help in transmitting or receiving media
  - They call it - wrongly!? – content
  - Media ARE content only if we handle art …

- Humans have the burden of exploring the features of their technical equipment
  - selecting media
  - dealing with devices for creating appropriate media
  - trying to interpret information delivered by media…

But what we really DO need is CONTENT

- It is not access to communication facilities which is important – it is access to the information!

- There is a potential for much better efficiency if we stop considering communication as
  - passing BITS and
  - start caring about THE PROPER INFORMATION

The phenomenon of the internet:
Providing storage of info and search for stored info

Does it help?

- Problem: I look after a baby… and work outdoors…
- Classical solution
  - Put a camera/mic in baby's room, transmit sound and video
    - ⇒Use (waste?) N Mbits/s, and I have to split attention

- New solution Put cameras/sensors close to the baby
  - Process the data and classify babies activity …
    - ⇒Alert me if babies activity changes…
    - ⇒How many bits ?
    - ⇒Isn't it less distracting? …

What are we aiming at ?

- Content will be
  - derived automatically from media
  - provided to people according to either their/somebody's explicit request or implicit recognition of needs based on the persons context and character
  - delivered in a form adjusted to the user's character, context and communication potential

- Desired distribution of content and required communication interactions within the relevant communities will be seamlessly supported

Cyber-Physical systems

- Cyber-Physical Systems (CPS) are integrations of computation and physical processes

- What's new?
  - size and power of computational elements
  - pervasive networking
  - sensing technology
  - actuation technology

- What's old?
  - modeling and design paradigms

More on Cyber-Physical Systems

- Some defining characteristics
  - Cyber capability in every physical component
  - Networked at multiple and extreme scales
  - Complex at multiple temporal and spatial scales
  - Dynamically reorganizing/reconfiguring
  - High degrees of automation, control loops must close at all scales
  - Operation must be dependable, certified in some cases

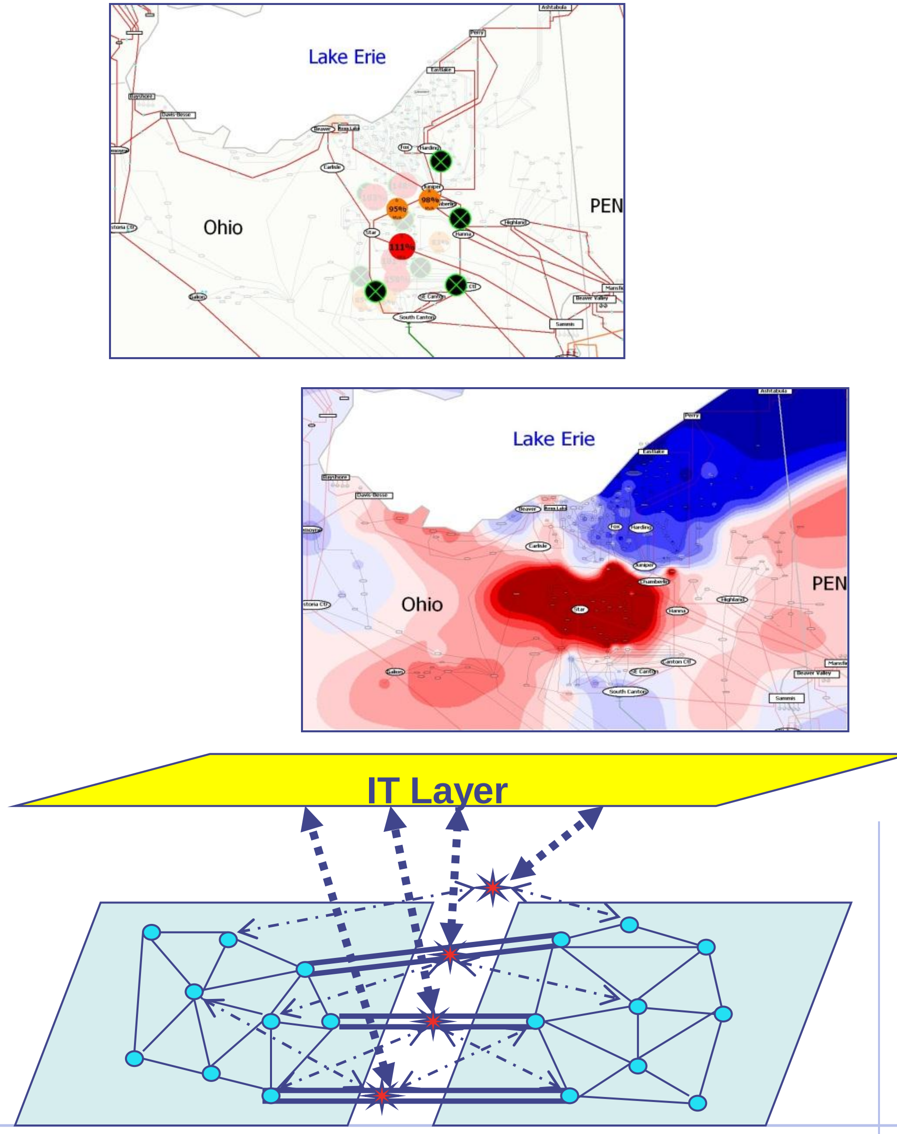
- What cyber-physical systems are not
  - Not desktop computing
  - Not traditional, post-hoc embedded/real-time systems
  - Not today's sensor nets

Example: Health Care and Medicine

- National Health Information Network, Electronic Patient Record initiative
  - Medical records at any point of service
  - Hospital, OR, ICU, …, EMT?
- Home care: monitoring and control
  - Pulse oximeters (oxygen saturation), blood glucose monitors, infusion pumps (insulin), accelerometers (falling, immobility), wearable networks (gait analysis), …
- Operating Room of the Future (Goldman)
  - Closed loop monitoring and control
  - Multiple treatment stations
  - Plug and play devices
  - Robotic microsurgery (remotely guided?)
  - System coordination challenge
- Progress in bioinformatics
  - gene, protein expression;
  - systems biology;
  - disease dynamics, control mechanisms

Example: Electric Power Grid

- Current picture
  - Equipment protection devices trip locally, reactively
  - Cascading failure: August (US/Canada) and October (Europe), 2003
- Better future?
  - Real-time cooperative control of protection devices
  - Or – self-healing –(re-)aggregate islands of stable bulk power (protection, market motives)
  - Ubiquitous green technologies
  - Issue: standard operational control concerns exhibit wide-area characteristics (bulk power stability and quality, flow control, fault isolation)



Pervasive Underlying Problems

- How to build predictable real-time, networked systems at all scales with integrated models of the physical world?
- How to formulate and manage high-confidence, dynamically-configured CPS?
- How to organize inter-operable “aggregated” systems?
- How to cooperatively detect and manage interference among systems in real time, avoid cascading failure?
- How to formulate an evidential (synthetic and analytic) basis for trusting systems?

Thank you very much

for the Attention!

We hope to see you soon in Distributed Systems, Computer Networks and many other lectures

Information on

OUR RESEARCH/COURSES/PROJECTS

follows