Lecture notes for SSY150: Multimedia and video communications

Wired/wireless networks for multimedia communications

(for lecture 8)

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Contents

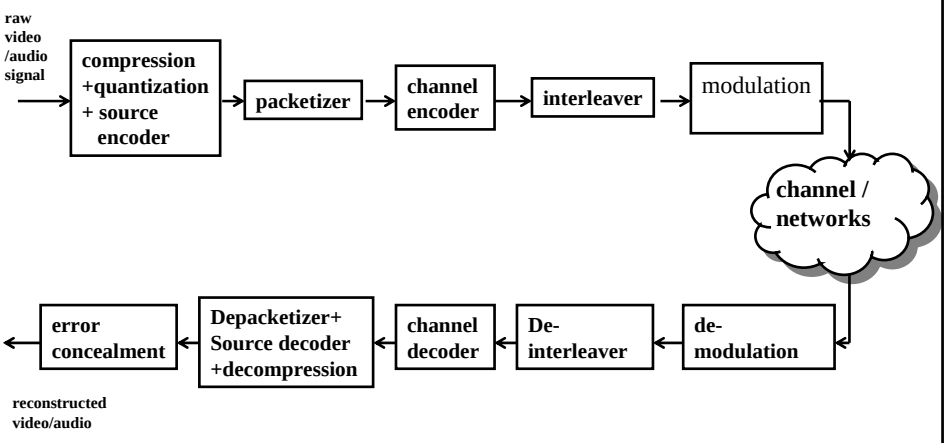
1. Motivations

Applications of multimedia communications:

- Video communications
- Video conferencing, video broadcast, video telephony, video streaming
- IP-phone, audio streaming
- Distance learning
- E-medicine, E-health care

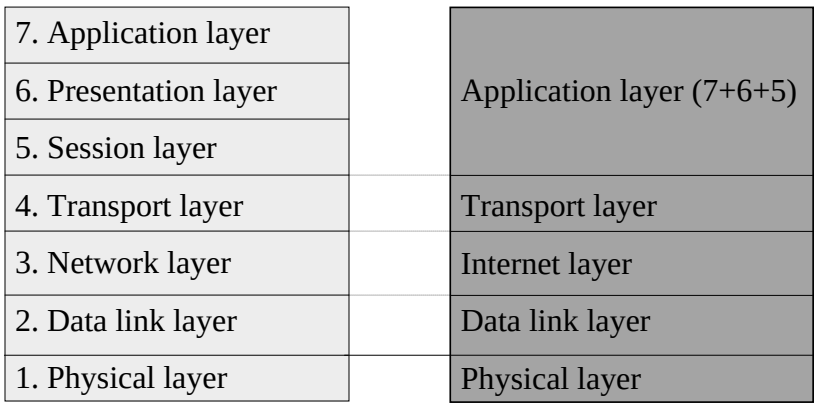
....

Multimedia communications



2. Network architecture: OSI 7-layer reference model and the IP model

OSI's 7-layer communication model vs. the 5-layer TCP/IP model



The OSI model

The TCP/IP model
(merge layers 5,6,7)

Functionalities of OSI's layers

1. **Physical-layer:** provides point-to-point, point-to-multipoint **bit** transport services over wires, optical fibers, or free space. Handles physical aspects, such as physical media, electrical impulse, transmitter power, modulation…
   Hubs are in this layer.

2. **Link-layer:** provides point-to-point, point-to-multipoint **packet** services (e.g. detect bit errors, re-transmit of lost/error packets), defines the format of data on the network. **Switches** are in this layer.

3. **Network-layer:** responsible for addressing, routing, and congestion control. It carries packets end to end across subnets (connected by **routers**). The path of packets is determined by routing protocols.

Functionalities of OSI's layers (cont'd)

4. **Transport-layer**: performs end-to-end error checking/correction and flow control. Transfers data between communication end points (or, end systems, hosts).
   TCP and UDP protocols are in this layer where the Internet architecture is primarily built on.

5. **Session-layer**: establishes/manages connection

6. **Presentation-layer**: ASCII Text, Sound (syntax layer)

7. **Application-layer**: services to users and programs, e.g. file transfers, http, email, video streams …

Functionalities of TCP/IP 5-layers

• Application Layer: contains the logic needed to support the various user applications. Each application requires a separate module.

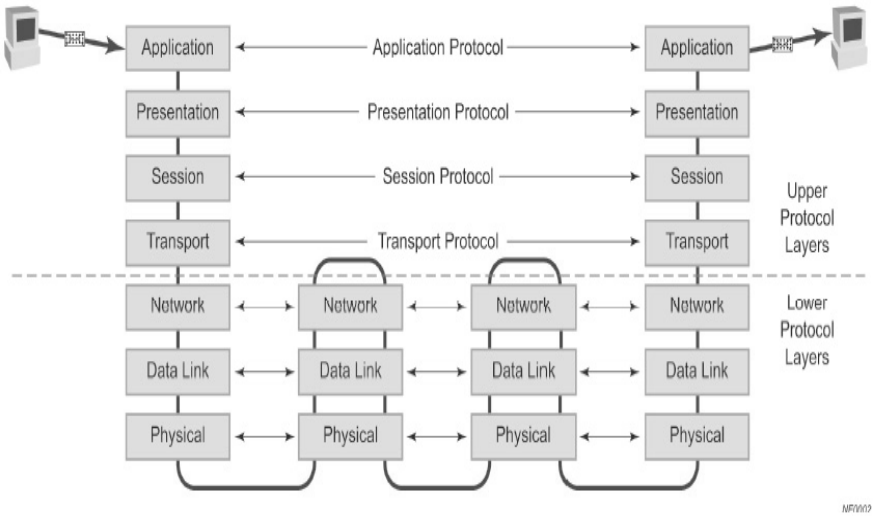
• Transport Layer: flow control and end-to-end error checking

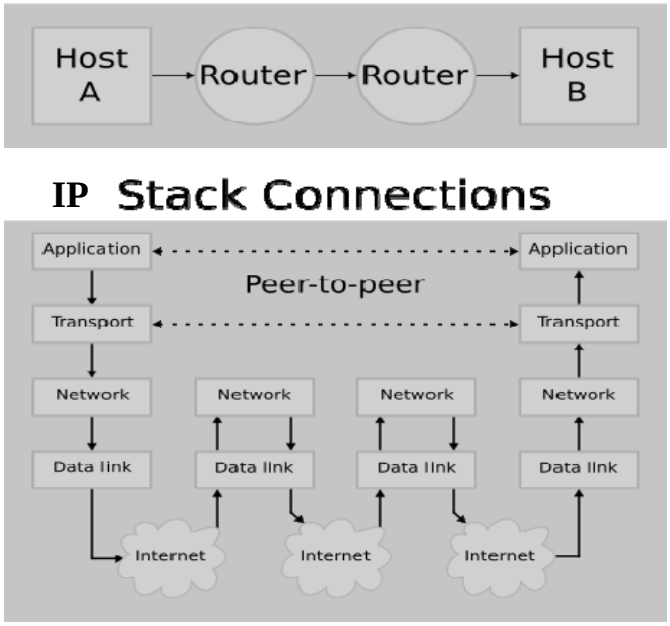
• Network /Internet Layer: IP provides the routing functions across multiple networks (routers)

• Data link layer: access and link data across a network between two end systems (switches)

• Physical Layer: covers physical interface between PC/ workstation and a transmission medium/network (Hubs)

Example: communication between 2 PCs





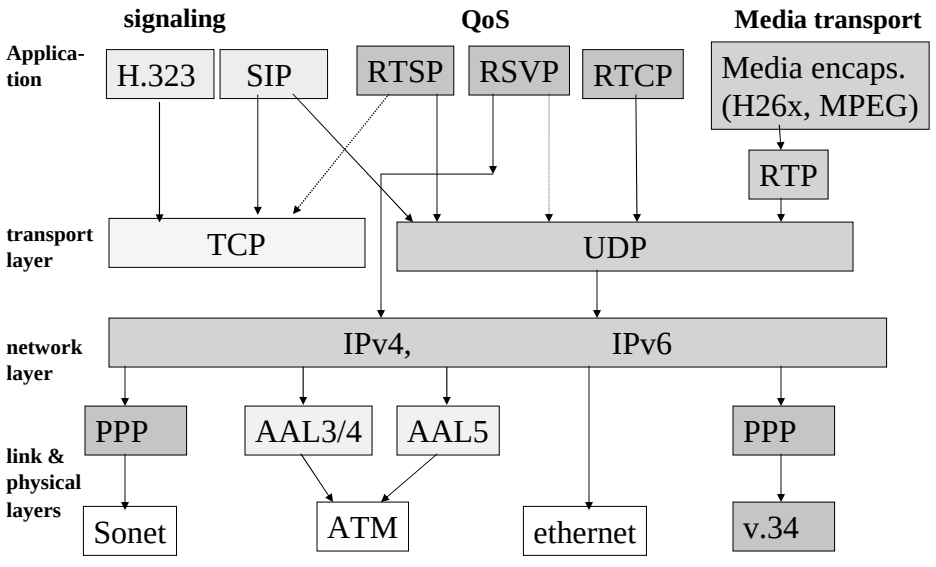
(from Wikipedia, the free encyclopedia)

3. IP Protocol Stacks

Protocols

- **Protocols are used for communications between networks, achieves:**
  - What, how, when, in which sequential order: is communicated between computers?
- **Key elements of a protocol:**
  - SYNTAC: Data format and signal levels
  - SEMANTICS: Control information for coordination and error handling
  - TIMING: Synchronization, speed matching, and sequencing
- **Examples of protocols:**
  - WAN Protocol: TCP/IP
  - LAN Protocol: Media Access Control (MAC); Contention; Token Passing

Internet multimedia protocol stack



Abbreviations of Protocols

SIP: Session initiation protocol (and H.323 for IP telephony)

RTSP: Real time stream protocol (for media on demand)
RTCP: Real time control protocol (for control, management)
RSVP: Resource reservation protocol

TCP: Transmission control protocol
UDP: User datagram protocol
RTP: Real time transport protocol

Transport Control Protocol (TCP)

- is for connection-oriented stream of bytes.
- provide window-based (buffer) positive acknowledgement (ACK) with a go-back-N re-transmission of lost or error packets (→ no packet loss).
- has its own congestion control.
- reliable sequenced byte stream service, in-order packets and reassembling packets.
- could introduce unbounded time delay due to persistent re-transmission
- not suitable for real time video applications

User Datagram Protocol (UDP)

- for connectionless datagram service;
- no re-transmission of lost packets;
- does not provide sequencing (or ordering) of packets;
- without its own congestion control mechanism;
- simple checksum option for verifying errors in arrived packets (currently, only intact packets are forwarded to the application layer);
- allows variable data length in data payload;
- does not provide reliable service;
- suitable for real time video applications.

Comparison: UDP vs TCP

	UDP	**TCP**
Packet loss	Yes	No
Data	Packet	Byte stream
Ordering	No	Always in order
Duplication	Possible	No
Multicast	Yes	No
Acknowledge	No	Yes

Internet protocol (IP): IPv4, IPv6

- uses a set of rules to send/receive messages at Internet address level
- Is a connectionless protocol (i.e. no established connection between end points that are communicating.)
- Responsible for delivery packets (while TCP for assembling packets)
- Is a data-oriented protocol for data communicating across a packet-switched inter-network.
- has checksum for the IP header (not for the data)
- is encapsulated in a data link layer protocol (e.g., Ethernet)

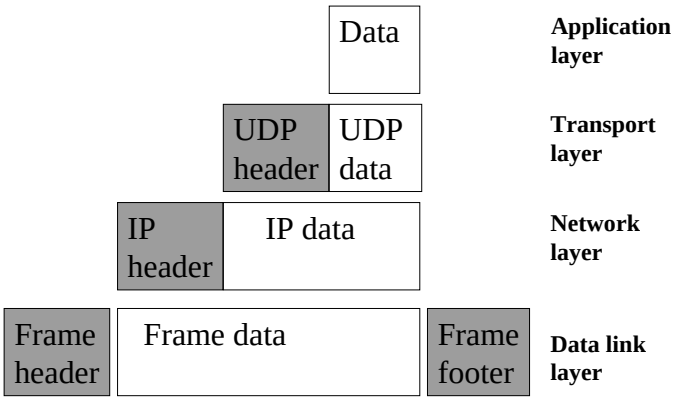
IPv4:

- designed for fixed networks and 'best effort' applications (with low network requirements, .e.g. email, file transfer).
- unreliable service that is subject to packet loss, reordering, duplication, unbounded delay. Not appropriate for real-time multimedia services.
- no mobility support

IPv6:

Includes some means of QoS and mobility support (suitable for IP-based wireless); More suitable for multimedia services

Example of data encapsulation



Efficiency: proportional to the ratio of header/data (payload)

(from Wikipedia, the free encyclopedia)

Real-time Transport Protocol (RTP)

- Operates in the application layer (usually in conjunction with UDP/IP) for real-time applications such as video and audio.
- Consists of data part and control part (called RTCP, Real-time Transport Control Protocol)
- Provides end-end network transport functions suitable for transmitting real-time data over unicast/multicast networks
- RTP payload formats are defined for a range of codes (e.g. H263, H261, JPEG, MPEG and some audio codes)

Real-time Streaming Protocol (RTSP)

- Operates in the application layer (on top of UDP/IP) for real-time stream applications
- Establishes and controls time-synchronized (one or multiple) media delivery with real-time constraints.
- It does not depend on use of RTP, or a particular media format (e.g. MPEG)

e.g. Application RealPlayer

Example: Protocols for Streaming Video

- Network-layer protocol:
  Internet Protocol (IP)

- Transport protocol:

– Lower layer: UDP & TCP

– Upper layer: Real-time Transport Protocol (RTP) & Real-Time Control Protocol (RTCP)

• Session control protocol:

– Real-Time Streaming Protocol (RTSP):
  RealPlayer

– Session Initiation Protocol (SIP):
  Microsoft Windows MediaPlayer; Internet telephony

Protocols/components in the 5-layer TCP/IP model:

5. Application layer

DHCP, DNS, FTP, Gopher, HTTP, IMAP4, IRC, NNTP, XMPP, POP3, SIP, SMTP, SNMP, SSH, TELNET, RPC, RTCP, RTSP, TLS, SDP, SOAP, GTP, STUN, NTP, RIP, ...

4. Transport layer

TCP, UDP, DCCP, SCTP, RTP, RSVP, IGMP, ICMP, ICMPv6, PPTP, ...

3. Network/Internet layer

IP (IPv4, IPv6), OSPF, IS-IS, BGP, IPsec, ARP, RARP, ...

2. Data link layer

IEEE 802.11, **Wi-Fi,** WiMAX, ATM, DTM, Token Ring, Ethernet, FDDI, Frame Relay, GPRS, EVDO, HSPA, HDLC, PPP, L2TP, ISDN, ...

1. Physical layer

Ethernet physical layer, Modems, PLC, SONET/SDH, G.709, OFDM, Optical Fiber, Coaxial Cable, Twisted Pair, ...

Wi-Fi: wireless fidelity

4. Wireless IP-based networks

Mobile IP

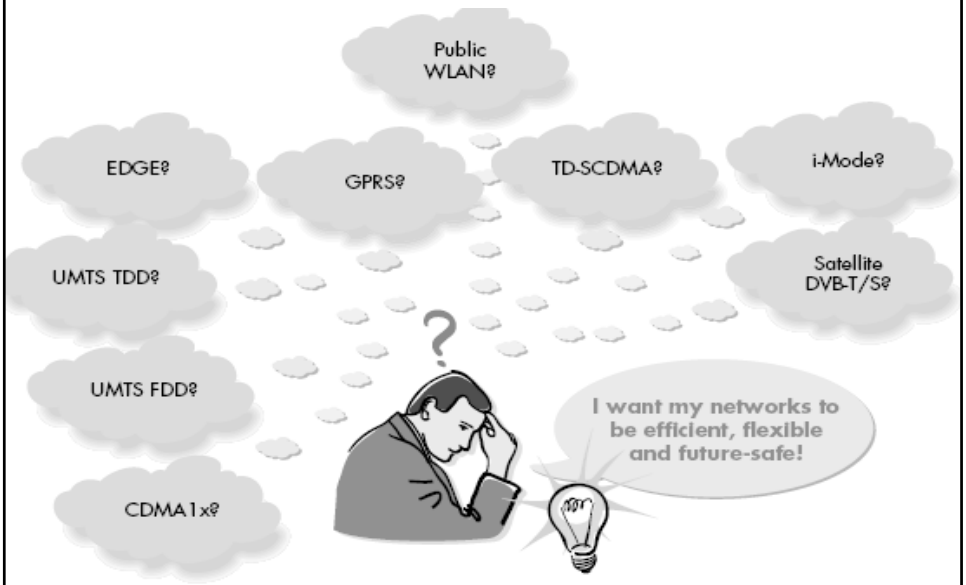
- Mobile IP is a standard which permits a mobile host to use a permanent IP address regardless of which sub-network it attaches to, through:
  - packet re-addressing,
  - registration of mobile agent,
  - encapsulation to forward datagrams to mobile host
- Mobile IPv4: with route optimization
- Mobile IPv6: solves triangular routing + some security issues

IP-based wireless networks

• Indoor systems based on IEEE 802.11 wireless LANs (WLANs). IEEE 802.11 is considered as wireless version of Ethernet, supporting the best effort service

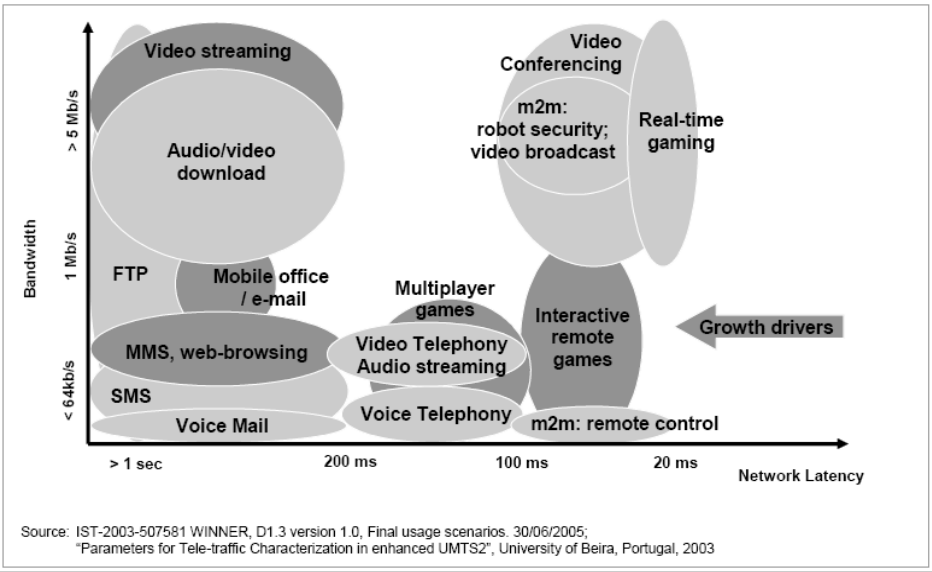
• Outdoor systems based on the emerging 3G and beyond 3G networks (e.g. CDMA2000)

Which network to select ?



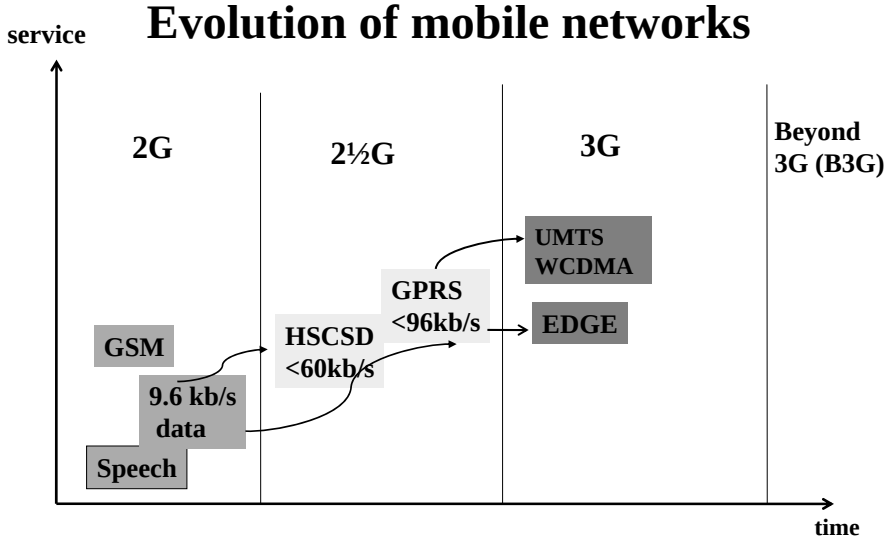
(This picture is obtained from a website)

Latency and bandwidths for various applications



Source: IST-2003-507581 WINNER, D1.3 version 1.0, Final usage scenarios. 30/06/2005;
"Parameters for Tele-traffic Characterization in enhanced UMTS2", University of Beira, Portugal, 2003

Evolution of mobile networks



UMTS: universal mobile transmission system
EDGE: enhanced data rates for GSM evolution
HSCSD: high-speed circuit-switched data
GPRS: general packet radio service

3G wireless systems aim at:

- provide high speed packet data services, multimedia services at any time and location
- provide variable-rate services for different propagation environments (in door, outdoor, pedestrian, vehicular)
- offer smoother interconnecting between different networks, environments
- provide global roaming (currently, different systems operate in different frequency in different parts of the world)
- converge different networks and wireless access technologies

General Packet Radio Service (GPRS) Networks

- Introduced in the GSM phase 2 standard
- Consists of packet wireless access network + IP based backbone
- Support packet data network, e.g. X.25, Internet
- Basic GPRS offers payload bit rate at 9-21.4kb/s, enhanced GPRS (EGPRS) at 8.8 - 59.2kb/s
- Support QoS negotiation for different service classes

EDGE (Enhanced Data rate for GSM Evolution) Networks

- Provide data rate between 64 and 384 kbit/s
- Provide 8 classes of link adaptation
- Modulation for downlink: 8-PSK, 3bits/symbol,
  for uplink: 8-PSK and GMSK
- Channel coding: rate 1/3 convolutional codes with memory 6 and different puncturing patterns

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UMTS (Universal Mobile Telecommunication Systems) Networks

- ETSI's standard: 3G system, supports voice, data multimedia services
- Infrastructure integrated with GSM (may perform both circuit and packet switching)
- The air interface for UMTS Terrestrial Radio Access Network (UTRAN) is WCDMA
- Major innovation is to incorporate packet-switching IP nodes.
- Main improvement over GPRS:
  IP mobility management and QoS control

Basic techniques for mobile communications

- TDMA-based (2G, GSM)
- CDMA-based (2G, IS-95 cdmaOne)
- OFDM-based

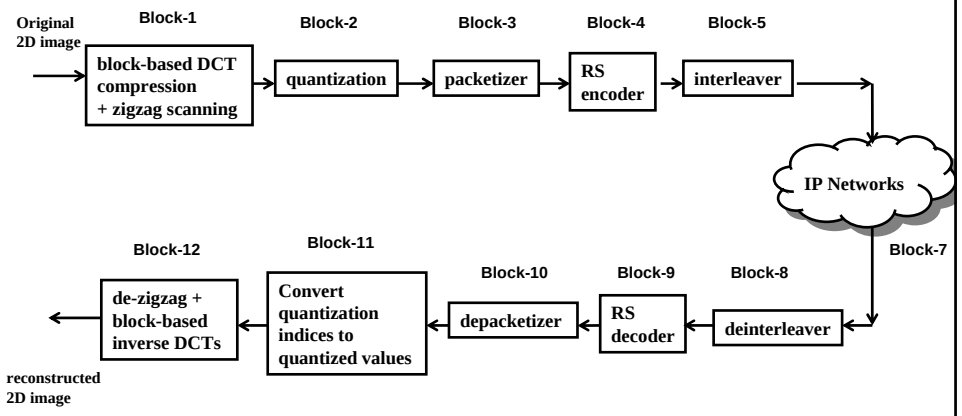
OFDM: Orthogonal Frequency-Division Multiplexing

Multiple access schemes

- FDMA (frequency-division multiple access)
- TDMA (time-division multiple access)
- CDMA (code division multiple access)
- OFDM (Orthogonal frequency-division multiplexing)

5. Laboratory exercise 4: description and demonstration

About laboratory exercise 4



Block diagram of end-to-end image communication system over IP networks, to be built and tested in Lab.4 (using communication toolbox)

What can we learn from Lab.4:

"Multimedia communications over IP networks" **?**

1. Building Matlab programs for the blocks of a simple multimedia communication system in the figure, using existing functions in the Matlab communication toolbox.

   include: 2D image compression, zigzag scanning, scalar quantization, RS codec, interleaving, and their inverse process.

2. Two sets of Tests:
   * the impact of packet losses (in the network layer) to the received image, under erasure network model.
   * the impact of bit errors (in the physical layer) to the received image.