Switching Technology
S38.165

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General

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  http://www.netlab.hut.fi/opetus/s38165

Goals of the course

- **Understand what switching is about**
- **Understand the basic structure and functions of a switching system**
- **Understand the role of a switching system in a transport network**
- **Understand how a switching system works**
- **Understand technology related to switching**
- **Understand how conventional circuit switching is related to packet switching**

Course outline

- Introduction to switching
  - switching in general
  - switching modes
  - transport and switching
- Switch fabrics
  - basics of fabric architectures
  - fabric structures
  - path search, self-routing and sorting

Course outline

- Switch implementations
  - PDH switches
  - ATM switches
  - routers
- Optical switching
  - basics of WDM technology
  - components for optical switching
  - optical switching concepts

Course requirements

- **Preliminary information**
  - S-38.108 Tietoliikenneverkkojen arkkitehtuurit or a corresponding course (S-72.423 Telecommunication Systems or T-110.300 Telecommunications architectures)
- **13 lectures (á 3 hours) and 7 exercises (á 2 hours)**
- **Calculus exercises are compulsory**
- **Grating**
  - Calculus 0 to 6 points
  - Min 2 points required for admittance to examination
  - Examination 30 points

Course material

- Lecture notes
- *Understanding Telecommunications* 1, Ericsson & Telia, Studentlitteratur, 2001, ISBN 91-44-00212-2, Chapters 2-4.
- J. Hui: *Switching and traffic theory for integrated broadband networks*, Kluwer Academic Publ., 1990, ISBN 0-7923-9061-X, Chapters 1 - 6.
- A. Pattavina: *Switching Theory - Architecture and Performance in Broadband ATM Networks*, John Wiley & Sons (Chichester), 1998, IBSN 0-471-96338-0, Chapters 2 - 4.
- T.E. Stern and K. Bala, *Multiwavelength Optical Networks: A Layered Approach*, Addison-Wesley, 1999, ISBN 0-201-30967-X.
- R. Ramaswami and K. Sivarajan, *Optical Networks, A Practical Perspective*, Morgan Kaufman Publ., 2nd Ed., 2002, ISBN 1-55860-655-6.

Introduction to switching

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Introduction to switching

- Switching in general
- Switching modes
- Transport and switching

Switching in general

ITU-T specification for switching:

"The establishing, on-demand, of an individual connection from a desired inlet to a desired outlet within a set of inlets and outlets for as long as is required for the transfer of information."

inlet/outlet = a line or a channel

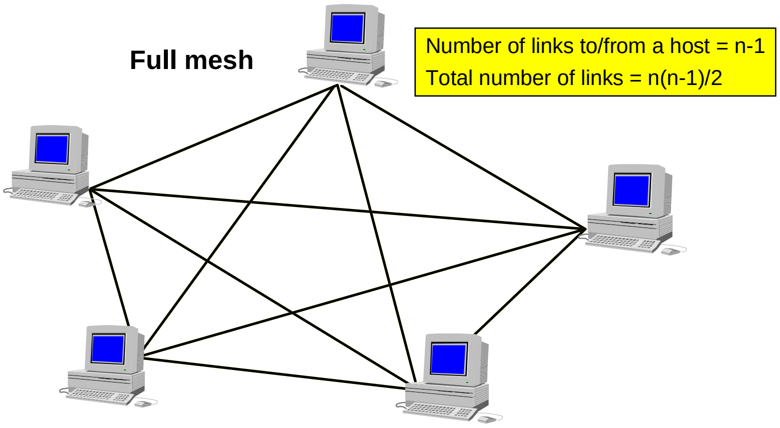
Switching in general

- Switching implies directing of information flows in communications networks based on known rules
- Switching takes place in specialized network nodes
- Data switched on bit, octet, frame or packet level
- Size of a switched data unit is variable or fixed

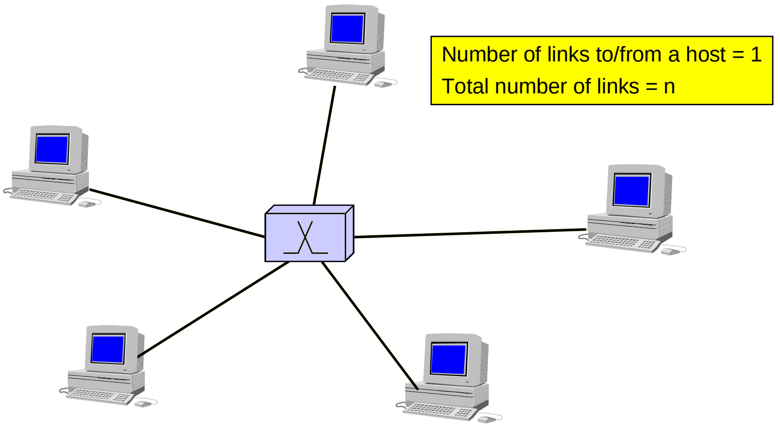
Why switching ?

- Switches allow reduction in overall network costs by reducing number and/or cost of transmission links required to enable a given user population to communicate
- Limited number of physical connections implies need for sharing of transport resources, which means
  - better utilization of transport capacity
  - use of switching
- Switching systems are central components in communications networks

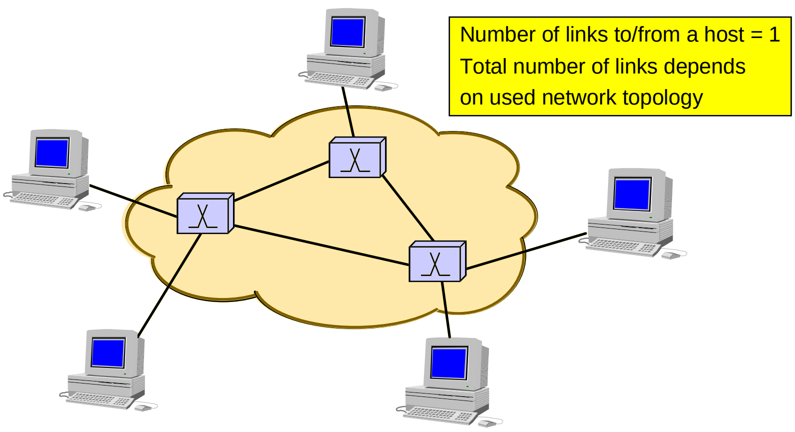
Full connectivity between hosts



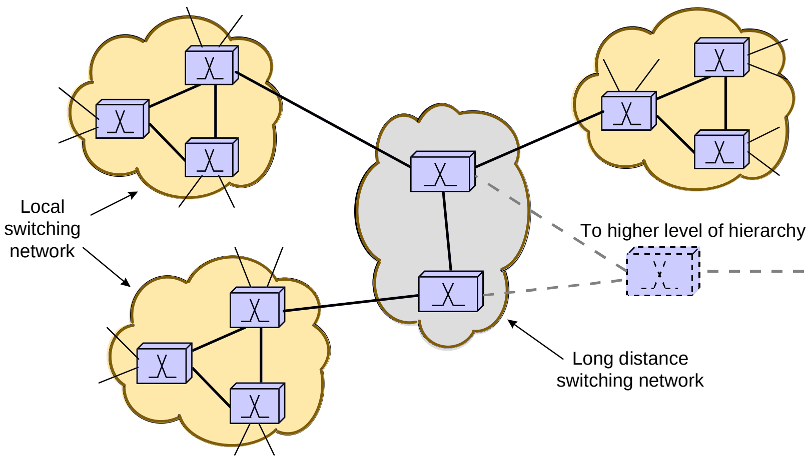
Centralized switching



Switching network to connect hosts

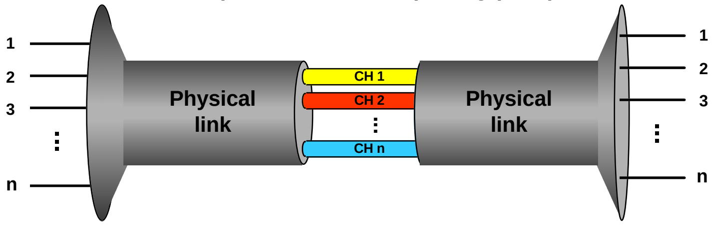


Hierarchy of switching networks



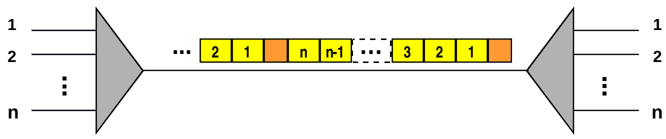
Sharing of link capacity

Space Division Multiplexing (SDM)

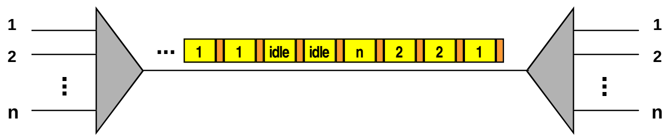


Sharing of link capacity

Synchronous transfer mode (STM)

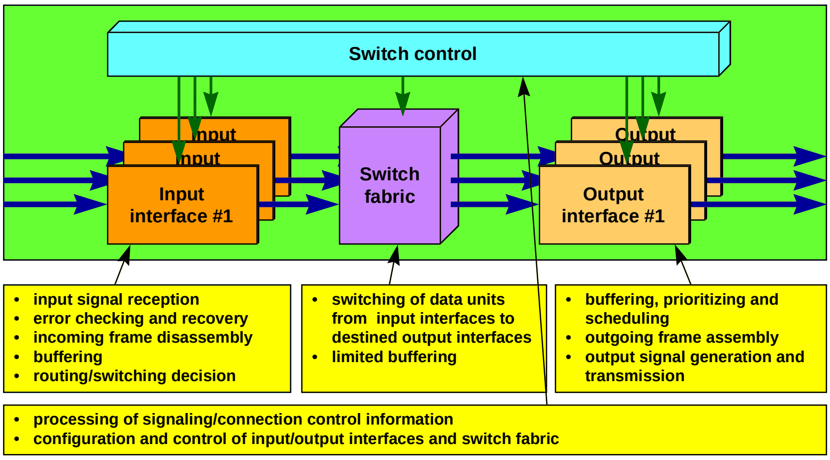


Asynchronous transfer mode (ATM)



Overhead k Payload

Main building blocks of a switch



Heterogeneity by switching

- Switching systems allow heterogeneity among terminals
  - terminals of different processing and transmission speeds supported
  - terminals may implement different sets of functionality
- and heterogeneity among transmission links by providing a variety of interface types
  - data rates can vary
  - different link layer framing applied
  - optical and electrical interfaces
  - variable line coding

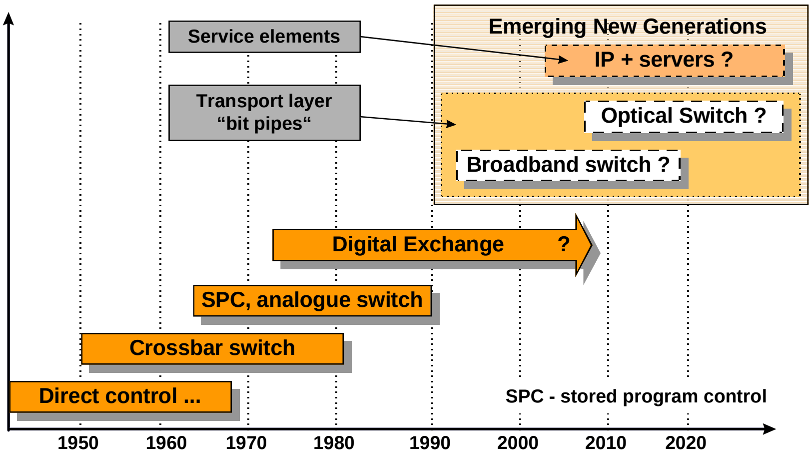
Basic types of witching networks

- Statically switched networks
  - connections established for longer periods of time (typically for months or years)
  - management system used for connection manipulation
- Dynamically switched networks
  - connections established for short periods of time (typically from seconds to tens of minutes)
  - active signaling needed to manipulate connections
- Routing networks
  - no connections established - no signaling
  - each data unit routed individually through a network
  - routing decision made dynamically or statically

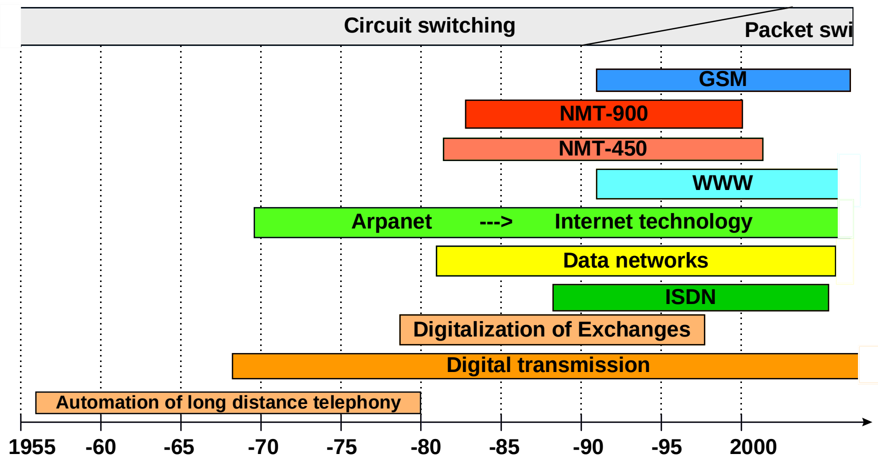
Key issues in modern switching

- Scalability
- Reliability
- Cost
- Throughput

Evolution of switching technologies



Roadmap of Finnish networking technologies



Switching modes

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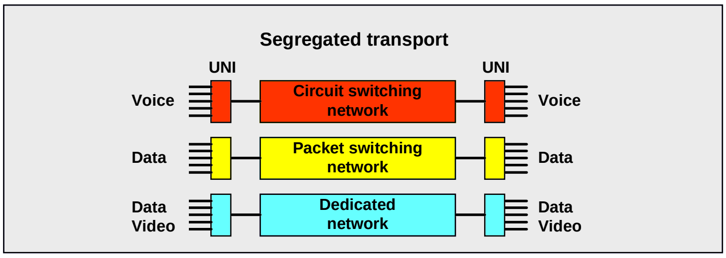
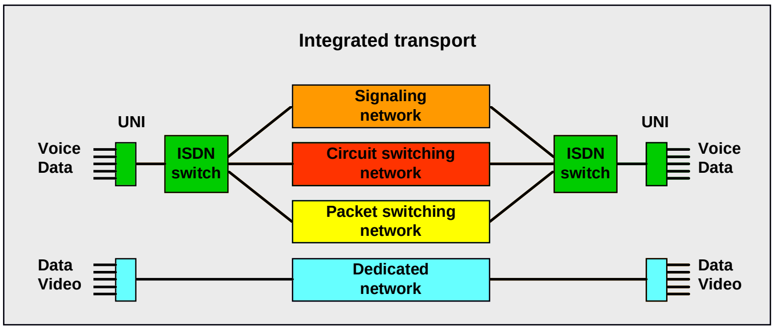
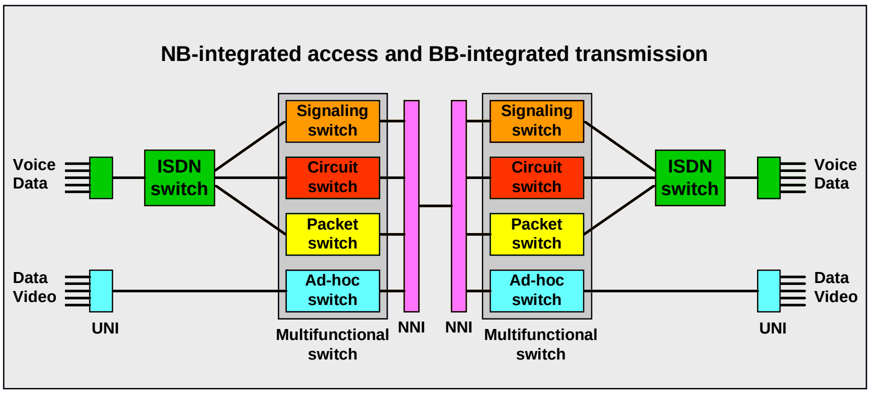
Narrowband network evolution



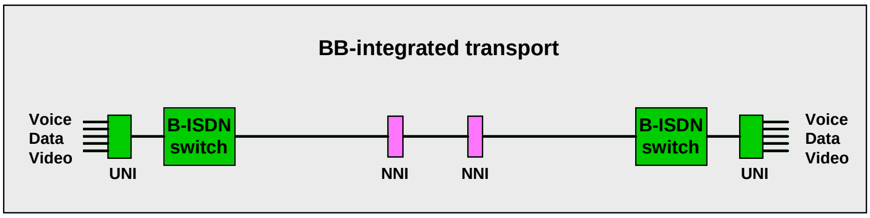
Narrowband network evolution (cont.)



Broadband network evolution

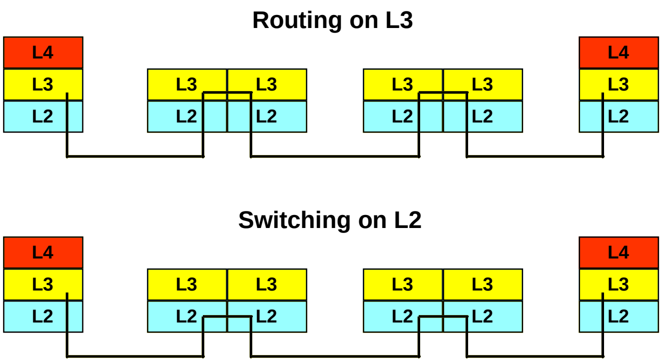


Broadband network evolution (cont.)



Basic definitions

OSI definitions for routing and switching

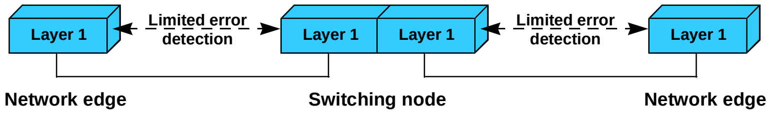


Switching modes

- Circuit switching
- Cell switching
- Packet switching
  - – Connection oriented
  - – Connectionless
  - – Layer 4 - 7 switching
  - – Label switching

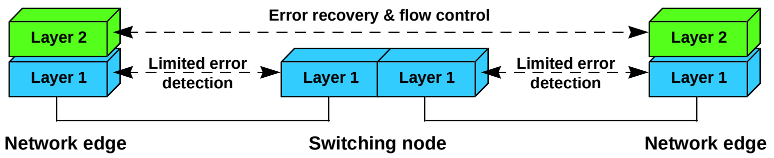
Circuit switching

- End-to-end circuit established for a connection
- Signaling used to set-up, maintain and release circuits
- Circuit offers constant bit rate and constant transport delay
- Equal quality offered to all connections
- Transport capacity of a circuit cannot be shared
- Applied in conventional telecommunications networks (e.g. PDH/PCM and N-ISDN)



Cell switching

- Virtual circuit (VC) established for a connection
- Data transported in fixed length frames (cells), which carry information needed for routing cells along established VCs
- Forwarding tables in network nodes

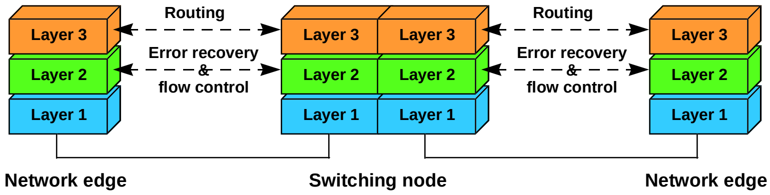


Cell switching (cont.)

- Signaling used to set-up, maintain and release VCs as well as update forwarding tables
- VCs offer constant or variable bit rates and transport delay
- Transport capacity of links shared by a number of connections (statistical multiplexing)
- Different quality classes supported
- Applied, e.g. in ATM networks

Packet switching

- No special transport path established for a connection
- Variable length data packets carry information used by network nodes in making forwarding decisions
- No signaling needed for connection setup



Packet switching (cont.)

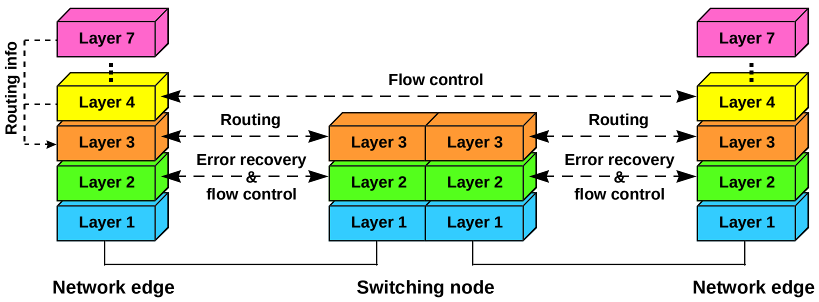
- Forwarding tables in network nodes are updated by routing protocols
- No guarantees for bit rate or transport delay
- Best effort service for all connections in conventional packet switched networks
- Transport capacity of links shared effectively
- Applied in IP (Internet Protocol) based networks

Layer 3 - 7 switching

- L3 switching evolved from need to speed up (IP based) packet routing
- L3 switching separates routing and forwarding
- A communication path is established based on the first packet associated with a flow of data and succeeding packets are switched along the path (i.e. software based routing combined with hardware based one)
- Notice: In wire-speed routing traditional routing is implemented into hardware to eliminate performance bottlenecks associated with software based routing (i.e., conventional routing reaches/surpasses L3 switching speeds)

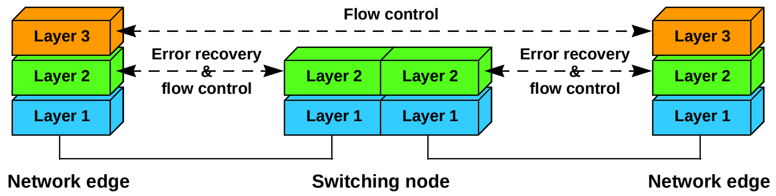
Layer 3 - 7 switching

- In L4 - L7 switching, forwarding decisions are based not only on MAC address of L2 and destination/source address of L3, but also on application port number of L4 (TCP/UDP) and on information of layers above L4



Label switching

- Evolved from the need to speed up connectionless packet switching and utilize L2 switching in packet forwarding
- A label switched path (LSP) established for a connection
- Forwarding tables in network nodes



Label switching (cont.)

- Signaling used to set-up, maintain and release LSPs
- A label is inserted in front of a L3 packet (behind L2 frame header)
- Packets forwarded along established LSPs by using labels in L2 frames
- Quality of service supported
- Applied, e.g. in ATM, Ethernet and PPP