Switching I

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Switching: Problem and Solution

- Problem
  - Each user can potentially call any other user, but…
  - We cannot afford having a direct line connecting each pair of users!.. We may not have direct lines at all.
- Solution
  - Switches establish temporary *circuits*
  - Switching systems come in two parts: *switch* and *switch controller*

Function of a Switch

- A switch transfers data from an input to an output
  - Many ports (up to 200,000 simultaneous calls)
  - Need high speeds

Importance of Switching

- The cost of switching is **high**!

Historical Remark

- The first telephone exchange opened in New Haven, Connecticut in 1878. The switchboard was built from carriage bolts, handles from teapot lids and bustle wire and could handle two simultaneous conversations.

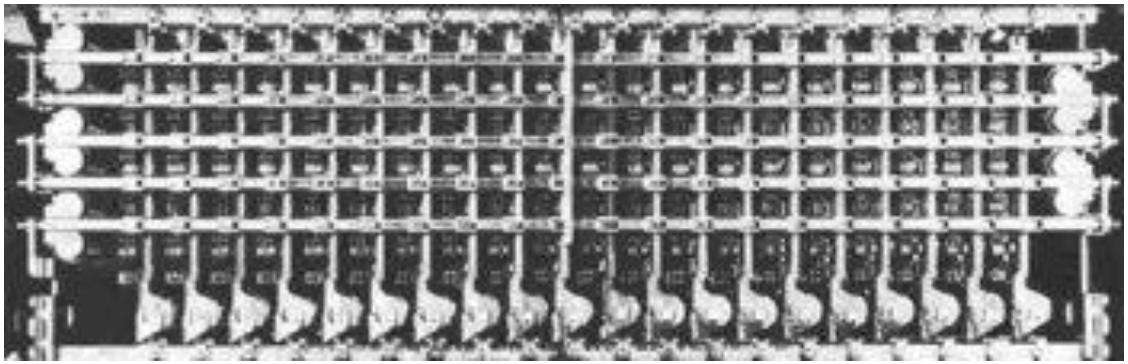
Definitions

- ***Switching*** is a technology designed to transfer input *sample points* to the correct output ports at the correct time
- ***Digital switching***: Sample point values are interpreted as 0's and 1's
- A ***private automatic branch exchange (PABX)*** is an automatic telephone switching system within a private enterprise
- A ***terminal*** or ***node*** is a device which is capable of communicating over a line; In a computer network, it’s a point where messages can be created, received, or transmitted

Circuit and Packet Switching

- A ***telecommunication circuit*** is a complete path between two terminals (nodes) over which one-way or two-way communications may be provided
- A ***circuit switching*** network establishes a fixed bandwidth circuit (or channel) between terminals (nodes) before the users may communicate, as if the terminals (nodes) were physically connected with an electrical circuit. The bit delay is constant during the connection.
- ***Packet switching*** is a communications paradigm in which packets (discrete blocks of data) are routed between terminals (nodes) over data links shared with other traffic. In each network node, packets are queued or buffered, resulting in variable delay.

Space Division



This is a typical Bell System Type B crossbar switch of the 1960s, with twenty verticals and ten levels. Crossbar switches use switching matrices made from a two-dimensional array of contacts arranged in an x-y format. These switching matrices are operated by a series of horizontal bars arranged over the contacts. Each such "select" bar can be rocked up or down by electromagnets to provide access to two levels of the matrix. A second set of vertical "hold" bars is set at right angles to the first (hence the name, "crossbar") and also operated by electromagnets. The select bars carry spring-loaded wire fingers that operate the contacts beneath the bars. When the select and then the hold electromagnets operate in sequence to move the bars, they trap one of the fingers to close the contacts beneath the point where two bars cross. This then makes the connection through the switch to connect the telephone call. The select magnet is then released so it can use its other fingers for other connections, while the hold magnet remains energized for the duration of the call to maintain the connection.

Stromberg-Carlson X-Y Switch

Stromberg-Carlson X-Y Switch was a modular switch that was horizontally slid into a vertical bay of shelves. An array of 400 (10X10X4) bare copper wires ran vertically behind the switch for the whole length of the bay. Four circuits were needed to make a connection: Tip, Ring, Sleeve, and Helper Sleeve. Each switch sat on shelf about 12"X9"X2" (2" high). When someone dialed a number, the retracted switch moved horizontally -- the X direction -- (left-to-right as you faced it from the front), one step for each dial-pulse. Then when the dialed digit stopped pulsing, the switch rapidly extended horizontally away from you as you faced it, with four contacts, one for each circuit -- T, R, S, and HS -- sampling the 10 possible phone trunks for an idle trunk to the next selector. The X-Y switch lifted no weight! The moving switch rested on the plate and moved only horizontally.

Time Division

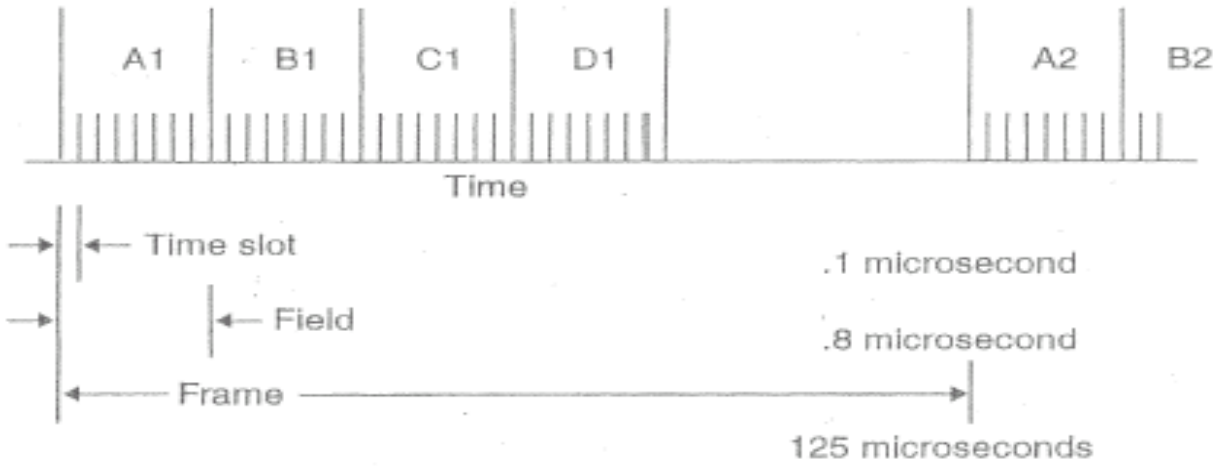
- ***Time-Division Multiplexing (TDM)*** is a type of digital or analog multiplexing in which two or more signals or bit streams are transferred apparently simultaneously as sub-channels in one communication channel, but physically are taking turns on the channel.
  - In 1962, engineers from Bell Labs developed the first D1 Channel Bank, which combined 24 digitized voice calls over a 4-wire copper trunk between Bell central office analog switches. A channel bank sliced a 1.544 Mbit/s digital signal into 8,000 separate frames, each composed of 24 contiguous bytes. Each byte represented a single telephone call encoded into a constant bit rate signal of 64 Kbit/s. A standard DS0 voice signal has a data bit rate of 64 kbit/s, determined using Nyquist's Sampling Criterion. More precisely…

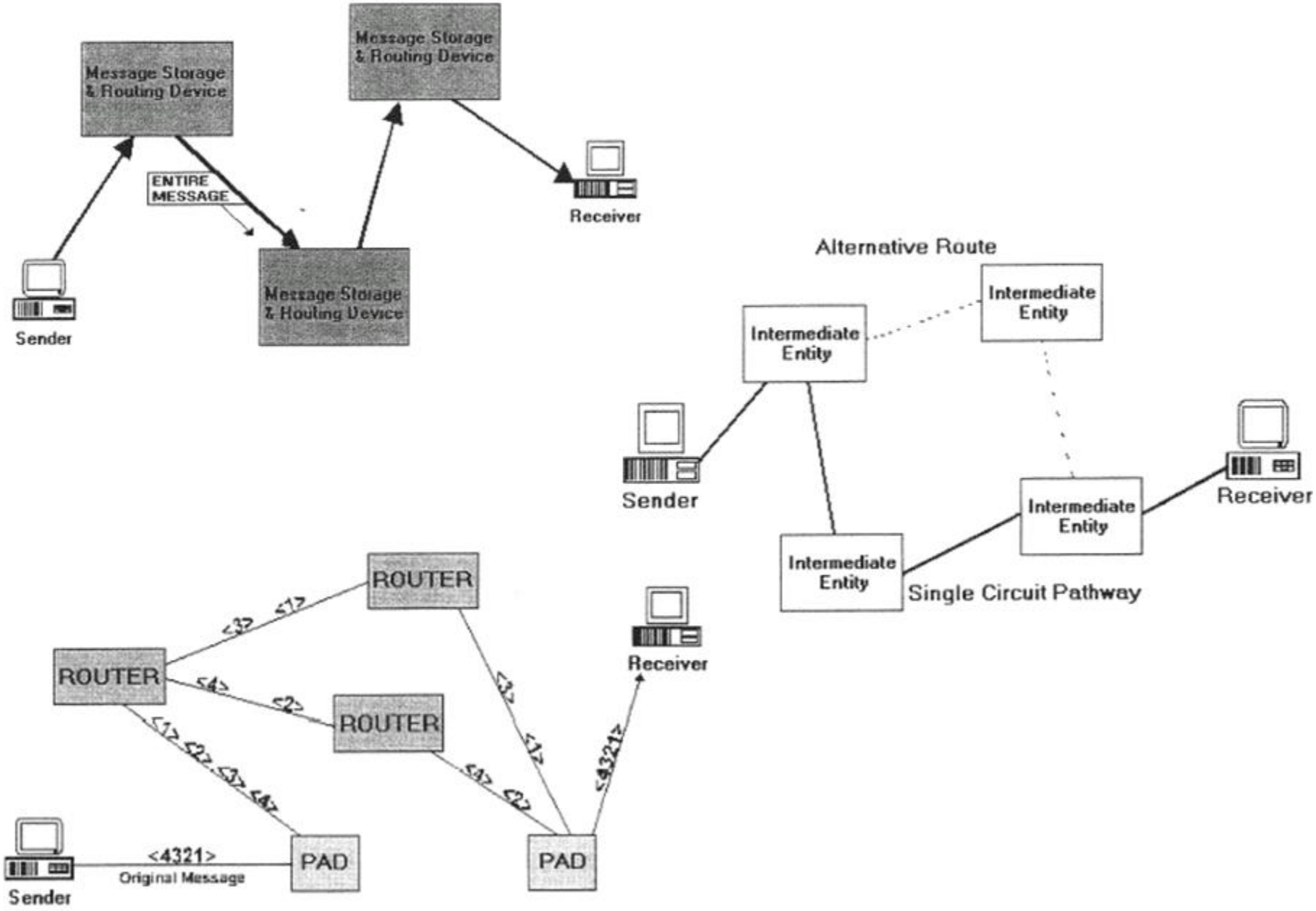
Voice digitization:

- W=3KHz, sampling at 2*3=6 or 8KHz
- 256 levels for quantization (8 bits)
- Bit rate=64Kb/s

Telephone switching

- Time-division multiplexing: time slot (0.1 ms), field, frame;
- 125ms/0.8=150 channels + time for synchronization and control




Message Storage & Routing Device
Message Storage & Routing Device
ENTIRE MESSAGE
Receiver
Sender
Message Storage & Routing Device
Alternative Route
Intermediate Entity
Intermediate Entity
Sender
Intermediate Entity
Intermediate Entity
Receiver
Single Circuit Pathway
ROUTER
ROUTER
ROUTER
Receiver
<3> <1>
<4> <2>
<1> <2> <3> <4>
<3> <1>
<4321>
<4> <2>
<4321>
Original Message
PAD
PAD
Sender

Switch architecture

- Sampling input signals, storing values in memory, placing values in the proper field and frame of the output sequence
- Need for more channels: hierarchical switching
- Combining time and space switching

General framework for switching

- time, space and frequency (broadband signals) switching
- synchronization (single clock) and buffering (memory)
- set-up time and delay (propagation time)
- "call duration" assignment vs. dynamic assignment
- in-band and out-of-band signaling

Circuit (synchronous) vs. packet (asynchronous) switching

- control and routing overhead, virtual packet switching