# TSN: Lecture 12
# Common Control

# Topics Covered

- Historical Switching
- Switchboard Plug
- Supervision Methods
- Call Connection
- Some Human Operator Features
- Strowger Step-by-step Switch

# Overview

- Switching software is real-time event-driven:
  - The driving events are end-user actions such as dialing digits, lifting or replacing handset, etc.
- Circuit-switched voice telephone software mimics the human interface behavior of historical electro-mechanical switches
  - Including incidental items like intentional post-dialing delay and non-symmetrical treatment of origin/destination vis-à-vis disconnect (wireline switches)
- Telephone switching software is often described or designed using finite state machine (FSM) formalism
  - Three isomorphic (equivalent) descriptions:
    - Graphical linked points diagram
    - Graphical flow-chart-like (SDL= specification and description language)
    - Tabular row-column lists

# Historical Switching

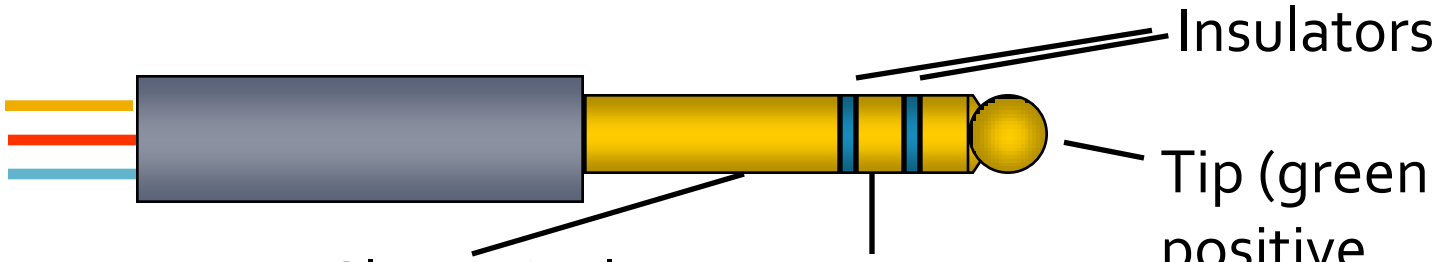
- Original 1876 A.G.Bell installations were point-to-point hard wired. Examples:
  - Office to warehouse of same firm (like a modern intercom circuit)
  - Palace to beach-house of the King of Hawaii
- Manual cord-board switching introduced in Hartford, CT in 1880s.
  - Teen-age boys pulled electric wires across the room and temporarily connected them in response to verbal instructions from subscribers
  - Later developments led to standard cord-board: a desk-like panel with a retractable cord from each voice connection unit, and a panel in front of the human operator with a socket for each subscriber (and historically later, a socket for each trunk line to another switching center)
  - Parallel historical development of common battery power and supervision technology also facilitated the cord switchboard

# Other 19th Century Improvements

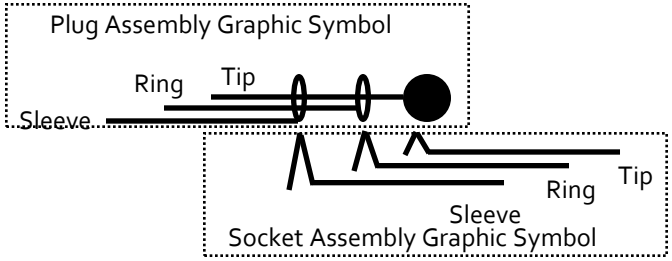
- Carbon Microphone (Edison and Berliner)
  - Permitted loops of up to ~5 mi (8 km) due to greater transmitted electrical audio power level
- 2-wire "loop," instead of single wire using earth conductivity for current return path
  - Earth return was previous standard in telegraph systems, but produced tremendous "cross-talk" for telephones
  - Loop greatly improved voice quality and reduced audio noise
  - Invented by J.J.Carty, later chief engineer of AT&T
- Alternating current ringer (low maintenance) instead of previous buzzer devices with vibrating electric contacts subject to sparking, corrosion and deterioration
- Common (central office) battery for dc loop current using transformer to couple audio voice signal between two telephones in a conversation

# Switchboard Plug

- Same dimensions used today for 1/4 in (6.35 mm) diameter stereo headset plug




Note: use of red insulation for negative polarity is unique to the telephone industry. Other electrical standards (power, electronics, automotive) use red for positive.

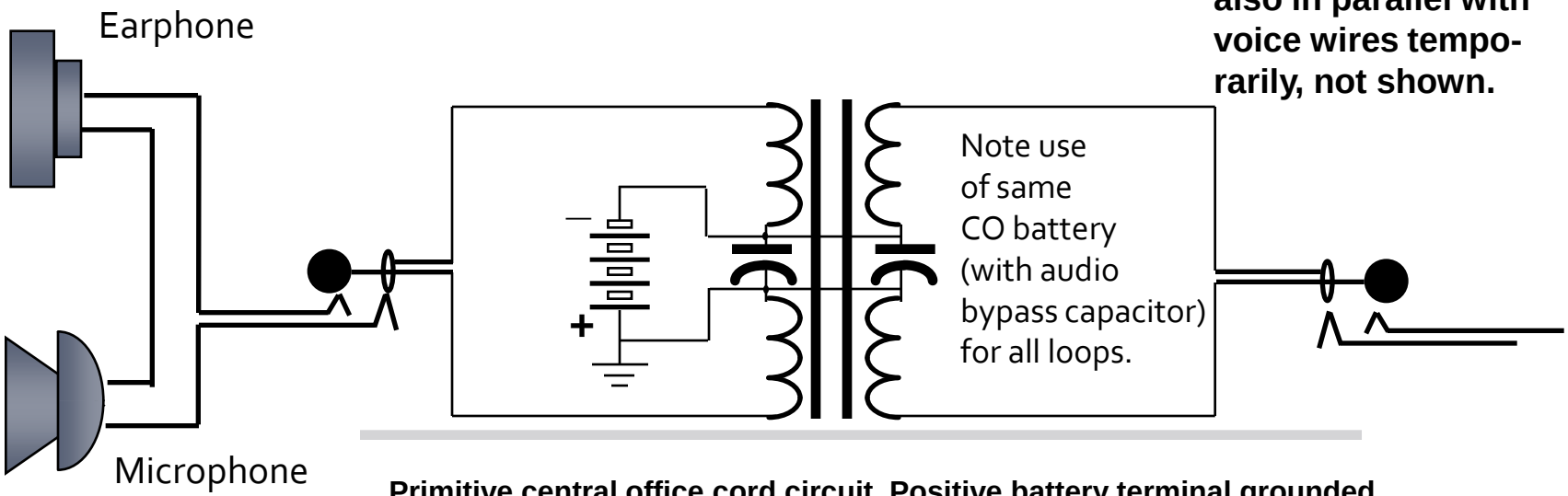


# Historical Cord Circuit

**telephone set and subscriber loop**

**Common battery feed and voice coupling**

**Other telephone set not shown. Operator headset also in parallel with voice wires tempo-rarily, not shown.**




**Primitive Telephone set (dial, ringer, cradle switch not shown). No directional coupler here as in later technology.**

**Primitive central office cord circuit. Positive battery terminal grounded to minimize electrolytic corrosion. Audio frequency voice signals coupled via transformer. Does not show ringing power, sleeve wires, signal lamps and buzzer, operator exclusion switches, etc.**

# Supervision Methods

- In traditional telephone jargon, "supervision" describes only the aspects of signaling which relate to busy/idle status
  - Dialed digit information was historically distinct (called "signaling")
  - In modern cellular/PCS software both things are often described by the word "supervision"
    - therefore, be careful about jargon!
- Historical method to get attention of the operator was a small hand-cranked AC generator or "magneto" at subscriber end
  - Produced about 90 V ac, at 20 Hz frequency.
  - Still standard ringing waveform for North America today
- Then the common-battery circuit was introduced
  - Subscriber "switch-hook" closed a current loop and operated a light and/or buzzer near that subscriber's socket on the switchboard panel
  - Operator lifted a retractable cord from the desk-top, connecting her* headset to the subscriber via a voice-frequency transformer
  - Operator then asked "Number Please?"

* Boys were replaced by more polite ladies in 1890's; operator corps was exclusively female until 1960s.

# Call Connection

- Operator plugged other end of cord circuit into callèd subscriber socket (the second syllable of callèd is artificially stressed in telephone jargon to emphasize the spoken distinction with "call")
  - Outer part of socket and "sleeve" (called "C" wire in European jargon) of plug carried a voltage when that line was busy. (No C wire in modern electronic switches.)
  - Voltage (if present) on sleeve produced an audible click in operator earphone, indicating busy line
- If callèd line is idle, cord circuit is plugged in, connecting voice circuit of both telephones
  - … and connecting temporarily the operator as well
  - Operator presses momentary contact switch to apply 20 Hz, 90 V ac ringing to the callèd loop
  - When callèd person answers, operator presses a latching switch to disconnect operator's headphone from the cord circuit
  - When either participant hangs up, dc loop current from common central office battery stops, indirectly operating a distinct buzzer and light on the cord board via a relay.
  - Operator then "tears down" the connection by pulling both retractable cord plugs from the callèd and calling part circuit sockets. Cords fall back into desk surface due to weights under the desk.

# Cord Switchboard Capacity

- The number of simultaneous conversations is limited to the number of cord circuits installed in a cord switchboard
  - Each cord circuit is similar to a storage address (byte) in an electronic switch vis-à-vis capacity
  - The BHCA (call processing) capacity is limited by the attention and operational speed available from the human operator
- Both were improved by providing more operator positions (cord circuits)
  - Each subscriber loop appeared at multiple sockets, each one within reach of an individual operator position
    - Thus a historical need for busy status signal (sleeve or C wire)
    - Early example of switch concentration
- Operator-handled calls were controlled by human intelligence
  - Computer controlled (stored program controlled - SPC) switches merely strive to put back into automatic service many of the clever things human operators did historically (example, ring back to originator when initially busy destination finally becomes available)

# Some Human Operator Features

- Call by name (no telephone number required)
  - Response to: "Please call the Smith home."
- Wake up calls (at pre-determined time)
- Re-connect calls accidentally disconnected*
- Notify busy line of incoming call waiting
- Set up 3-way (or more) conference call
- Connect call to alternate line when subscriber is away from home (call forwarding)

Note that modern "feature-rich" PBX, small business key systems, and some PSTN switches now do these things via computer control

- Several experts have calculated that there are not enough people on earth to support the today's (2001) level of public telephone traffic using operator cord board switching!

*The GSM cellular system can optionally be configured to do this.

# Strowger Step-by-step Switch

- Almon B. Strowger, a mortician (undertaker) in Kansas City KS, invented the first practical automatic dialing system
  - Famous story: fearing that the human operator was directing calls for a mortician to his competitor, he invented an automatic user-controlled switch
  - First version (installed in LaPorte, IN, circa 1895) used extra wires and push buttons on each subscriber set
  - Rotary dial with impulsive current on the voice wire pair was a later development
- Strowger's manufacturing firm, Automatic Electric, moved to suburban Chicago, IL, later absorbed by GTE, later moved to Phoenix AZ, now AG Communication Systems (partly owned by Lucent)
  - "Stepper" progressive control switches were manufactured world wide for many decades
  - Electromechanical common-control switches developed by other manufacturers, such as "panel" and "crossbar" types partially succeeded steppers in the 1930 - 1960 decades