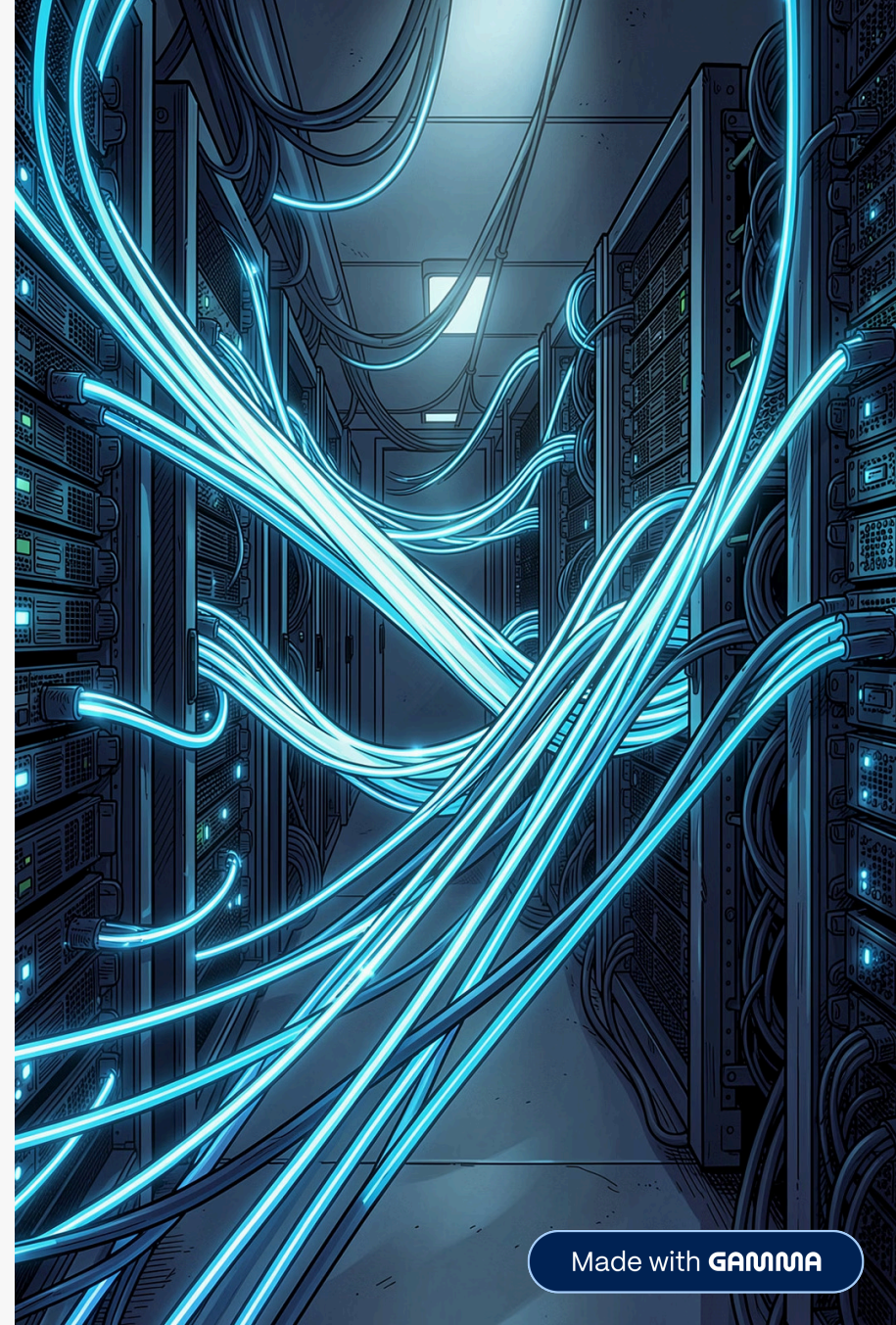
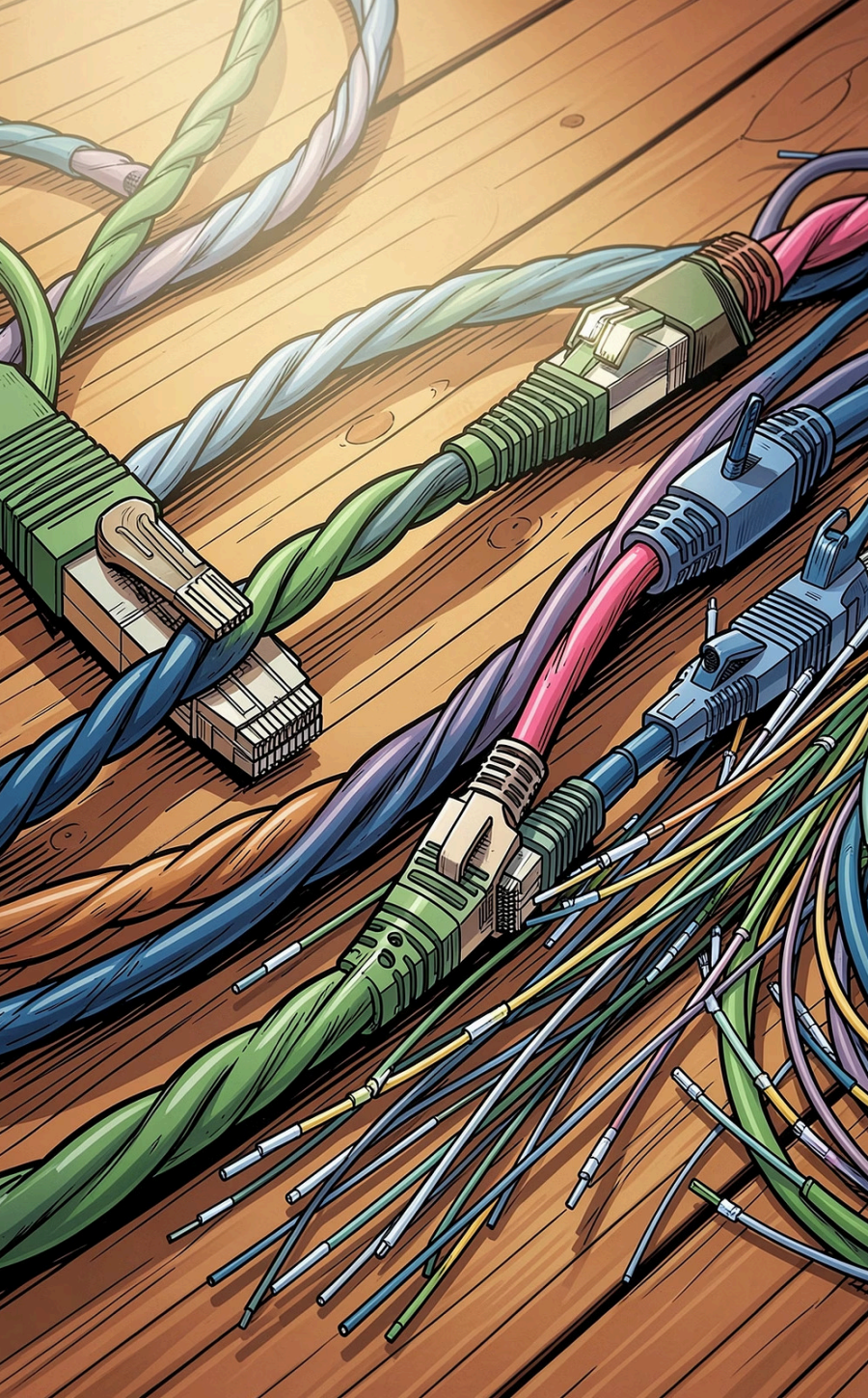


From Signals to Switches: The Evolution of Connectivity

A deep dive into the physical pathways, switching architectures, and multiplexing technologies that underpin modern communication networks.





The Foundation: What is Transmission Media?

Transmission media is the **physical or logical pathway** over which information travels between sender and receiver – the very backbone of any network.

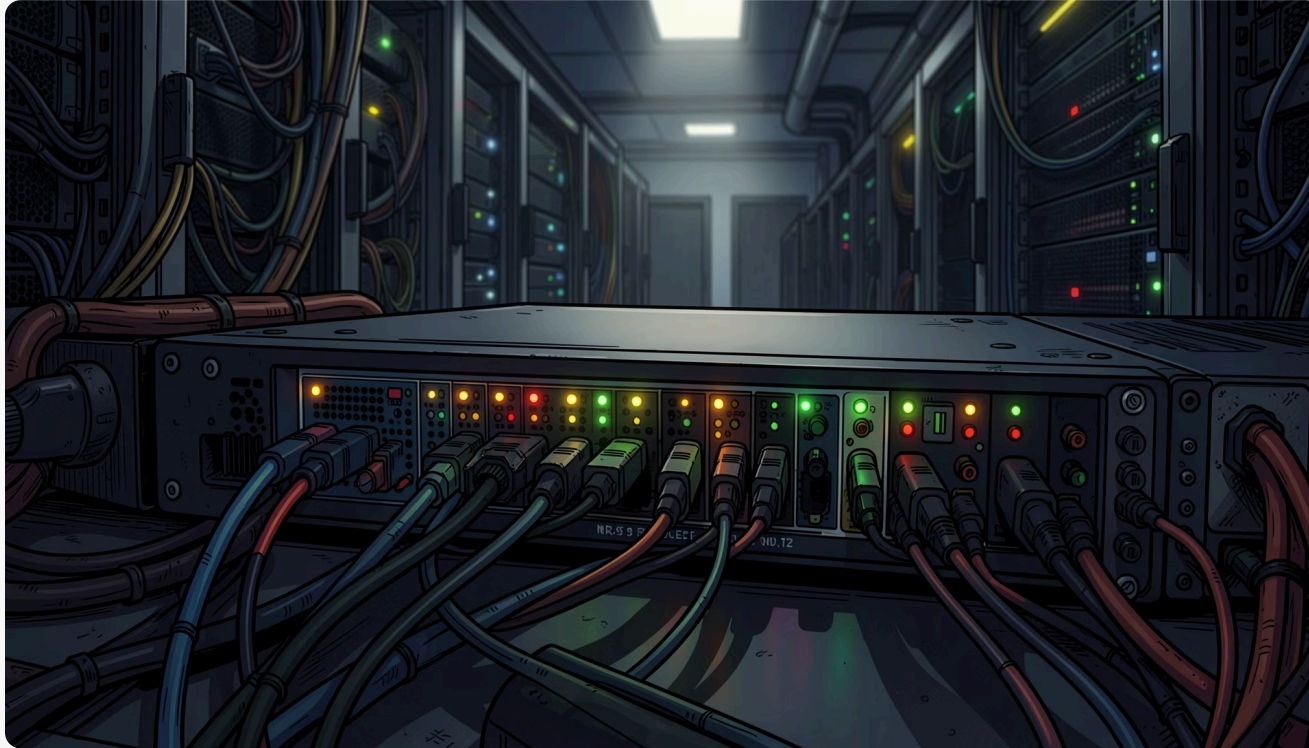
Guided Media

Physical conduits that direct signals along a contained path – twisted-pair, coaxial, and fibre-optic cables.

Unguided Media

Wireless transmission propagated through open space – radio waves, microwaves, and satellite links.

The Art of the Connection: What is Switching?



Switching is the mechanism that enables **efficient movement of traffic** between network nodes – determining how data finds its path from source to destination.

Circuit Switching

A dedicated, reserved path for the full duration of a session.

Packet Switching

Data broken into packets, each routed independently across the network.



Circuit Switching: The Dedicated Path

Fixed Route

A dedicated communication path is established and maintained exclusively between two stations for the entire session.

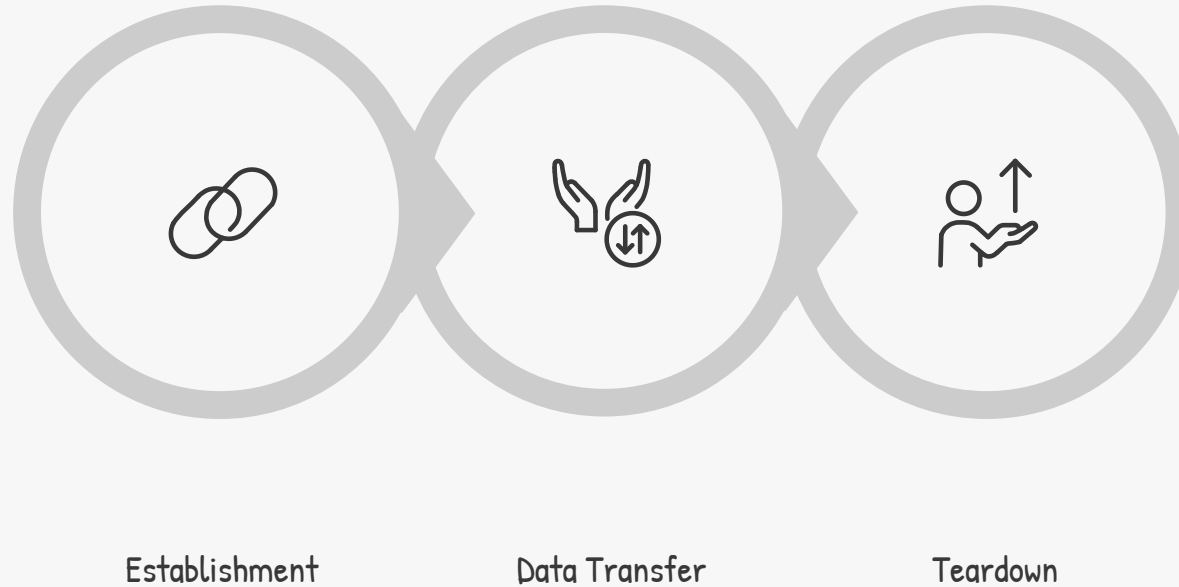
Real-Time Performance

No queuing or delay at intermediate switching nodes – data flows continuously and predictably.

Reserved Resources

Bandwidth and switching capacity are fully reserved, guaranteeing consistent quality of service throughout the connection.

The Three Phases of a Circuit



Every circuit-switched connection follows this disciplined lifecycle – resources are committed at establishment and not freed until teardown, ensuring exclusive use of the channel throughout data transfer.

Evolution: From Manual to Automatic

Manual Era

Human operators at crossbar switchboards physically connected calls by hand — slow, labour-intensive, and error-prone.

Electronic Exchanges

Mechanical relays gave way to electronic switching systems — faster, quieter, and capable of far greater call volumes.



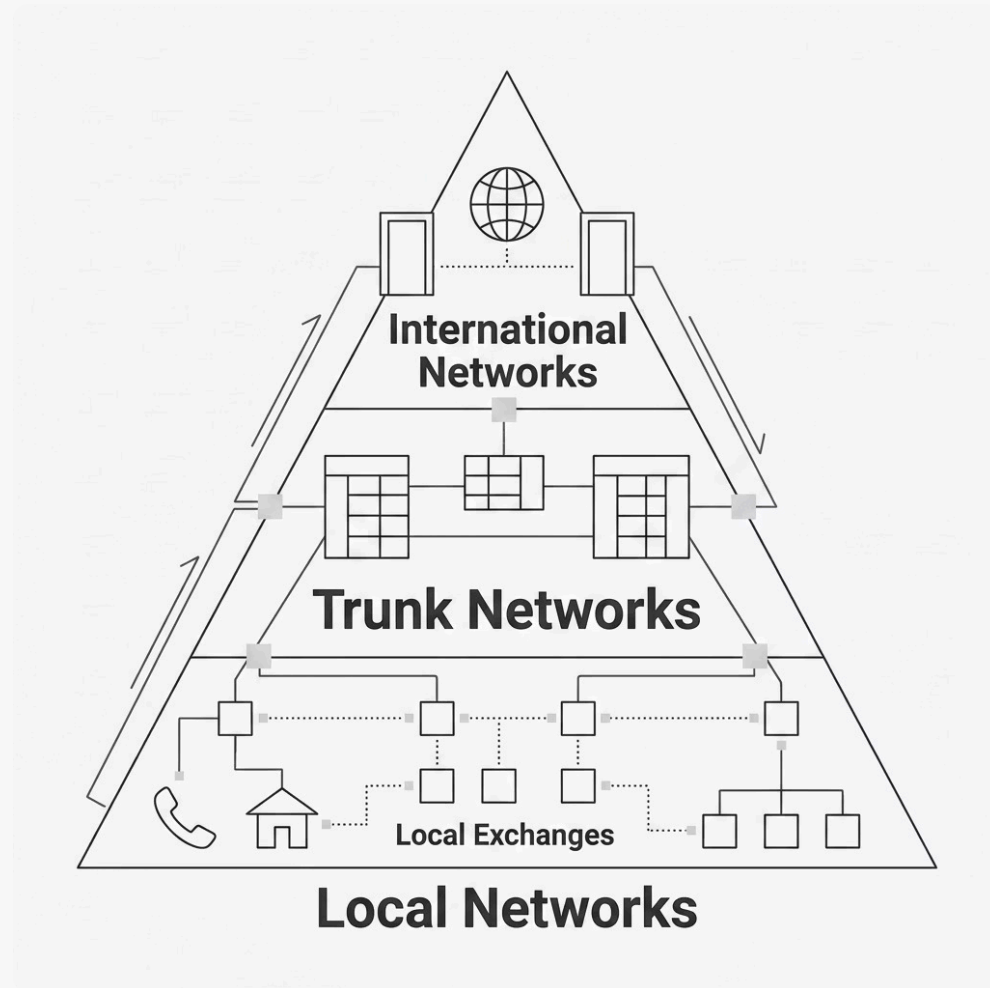
Strowger Revolution

Almon Strowger's step-by-step selector (1891) automated switching, eliminating operators and dramatically increasing capacity.

Digital Era

Digital exchanges transformed voice into data, enabling integration with computer networks and paving the way for the modern Internet.

PSTN: The Public Switched Telephone Network



The PSTN is a **hierarchical architecture** of interconnected switching nodes, designed to route calls efficiently across any distance.

- **Local networks** connect individual subscribers to their nearest exchange
- **Trunk networks** carry high-volume, long-distance traffic between regional centres
- **International gateways** bridge connections across national borders and global regions

Optimising the Path: Multiplexing Techniques

Multiplexing allows multiple signals to share a single transmission link – maximising efficiency in bandwidth-constrained environments.



Frequency Division Multiplexing (FDM)

The link is divided into distinct **frequency channels**, each carrying a separate signal simultaneously – common in analogue telephone and cable systems.

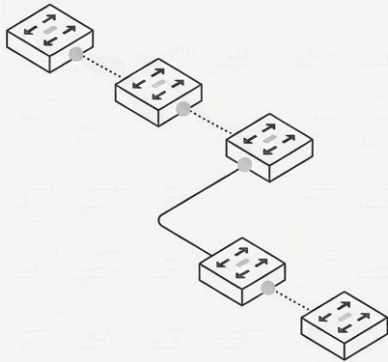


Time Division Multiplexing (TDM)

The link is divided into **time slots** allocated cyclically to each signal – widely used in digital telephony and synchronous data networks.

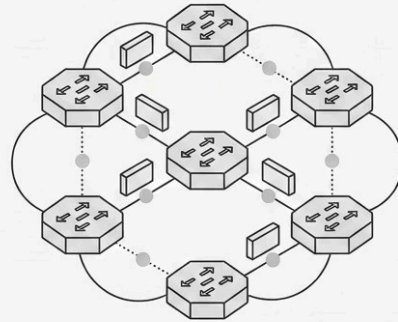
Circuit vs Packet: A Strategic Comparison

Circuit Switching



Dedicated Path
Reserved Bandwidth
Consistent Latency
Voice Traffic
Resource Wastage

Packet Switching



Shared Path
Dynamic Bandwidth
Variable Latency
Internet Traffic
Efficient Resource Use

The fundamental trade-off in network design: **dedicated paths** deliver stability and guaranteed performance, while **packet networks** offer scalability and efficient resource utilisation.

i The modern Internet is built on packet switching – yet circuit switching remains essential for real-time voice and legacy telephony infrastructure.

Conclusion: The Future of Network Intelligence

The journey from copper wire to software-defined networks reflects decades of relentless innovation in connectivity.

- **Intelligent Traffic Management**
Modern switches manage complex, multi-layered flows across voice, video, and data — simultaneously and at scale.
- **Software-Defined Networking**
Control planes are increasingly decoupled from hardware, enabling dynamic, programmable, and adaptive network architectures.
- **Always Connected**
Connectivity remains the vital pulse of global communication — and its evolution is far from over.

