Circuit Switching is Inefficient

• Silence not suppressed:
  – One direction is silent almost 100%.
  – Even the speaker’s channel has lots.
• PCM isn’t very aggressive compression.
• Packet switching improves bandwidth utilization!
Circuit Switching is Expensive

- Packet-switched networks are cheaper to deploy.
  - Instead of CO switches, deploy
    » Routers
    » Gateways
    » Proxies/Gatekeepers

- But also -- plenty of marketing fluff
Down At The CO

- SS7
- STP
- Connection to SS7 Network
- Class 5 CO
- Control Computer
- Switching Fabric
- PSTN
- Connection to customers
- Interoffice Trunks: Connection to other switches
Changes Down At The CO

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Let’s Explode the CO

• Having decomposed the CO into components connected with an IP network, we can put the components anywhere we want.
Next Generation Networks

- Companies w/ all-packetized core nets.
  - Sometimes called NextGen telcos
    » [very poorly defined term]
  - Examples:
    » Level 3 Communications
    » http://www.level3.com
- Traditional telephony carriers are headed the same way.
Next Generation Network
From “NGN Protocols”

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Next Generation Network
With Phil’s Modification
NGN Protocol Stack

SIGTRAN

IPv4/IPv6

Network Layer Protocols

TCP

UDP

User Adaptation (IUA, M3UA, M2UA, M2PA SUA, V5UA)

Application Layer Protocols

H.323

H.248

SIP

RTCP

RTP
Another Transport Protocol?

• TCP:
  – Single connection has a single stream of data.
  – Reliable, but absolutely sequential.
  – Connects to single NIC

• UDP
  – Unreliable, not sequential.
Problems with TCP for Signal Transfer

- Head-of-line blocking:
  - An order-preserving TCP connection causes delivery of messages sent later to be delayed within a receiver's transport layer buffers until an earlier lost message is retransmitted and arrives.
  - These later messages often establish independent telephone calls. For call control signaling, the delay on later messages caused critical call control timers to expire thus resulting in undesirable call setup failures.
Problems with TCP for Signal Transfer

• Single connection:
  – A TCP connection only binds a single point of attachment at either end point.
  – Consider a host with multiple points of attachment to the Internet, for redundancy. If one fails, it often takes minutes for new routing to be set up.
  – For call control signaling, such delay is unacceptable when an alternate available path exists.
Another Transport Protocol – SCTP

• Multihomed - Each of the two endpoints during an SCTP association setup can specify multiple points of attachment.

• Message Oriented - In SCTP, message boundaries are preserved.
  – If an application sends a 100-byte message, the peer application will receive all 100 bytes in a single read: no more, no less.
  – In TCP, data sent between two endpoints is a stream of bytes. If needed, an application must provide message framing.
Multihoming
SCTP is also:

• **Un-Ordered Reliable Service** –
  - SCTP offers the reliable delivery of messages with no order constraints.
  - In TCP, all messages are reliably delivered to a receiving application in exactly the order used by the sending application. UDP provides unordered service without reliability.
Multi-streaming

Peer

Stream 0

Stream 1

Stream 2

Stream N

SCTP Association

Peer
SCTP:

• Heartbeat/Keep-alive –
  – SCTP has a default keep-alive function. Regular heartbeats validate reachability of peer addresses, and help maintain a Round Trip Time (RTT) estimate for each alternate address.
SCTP Packet Format

- 32 Bit
- Source Port
- Destination Port
- Verification Tag
- Checksum
- Type
- Flags
- Length
- User Data
- SCTP Common Header
- Chunk 1
- Chunk N
## Chunk Types

<table>
<thead>
<tr>
<th>ID</th>
<th>Chunk Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Payload Data (DATA)</td>
</tr>
<tr>
<td>1</td>
<td>Initiation (INIT)</td>
</tr>
<tr>
<td>2</td>
<td>Initiation Acknowledgement (INIT ACK)</td>
</tr>
<tr>
<td>3</td>
<td>Selective Acknowledgement (SACK)</td>
</tr>
<tr>
<td>4</td>
<td>Heartbeat Request (HEARTBEAT)</td>
</tr>
<tr>
<td>5</td>
<td>Heartbeat Acknowledgement (HEARTBEAT ACK)</td>
</tr>
<tr>
<td>6</td>
<td>Abort (ABORT)</td>
</tr>
<tr>
<td>7</td>
<td>Shutdown (SHUTDOWN)</td>
</tr>
<tr>
<td>8</td>
<td>Shutdown Acknowledgement (SHUTDOWN ACK)</td>
</tr>
</tbody>
</table>
Setting Up an SCTP Connection

TCP 3-way handshake

SCTP 4-way handshake
Consider an Ordinary LD Call:

- What goes on inside the IXC network? Who cares?

- Digital or Analog?
- TDM or FDM?
- Fiber or Copper?
- SS7 or Hierarchical?
Thinking of Service Provision as Clouds

Core:
• Service provider’s concern
• Can be anything the provider finds useful.

Edge:
• Where service provision actually happens
• Connects to user in specified way
Of Course, We Deal w/ Multiple Providers

Verizon

FrogNet

Internet

at&t

Loretto Telephone

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What’s In It For Us?

• Lower telco costs
  ⇒ Lower prices and/or more stable telcos?
How About This?

- Customer interacts with network in packetized way.

Regional Office
Corporate Voice/Data LAN

Vendor Packet Network

HQ
Corporate Voice/Data LAN
Or This?

- Provider can deliver voice to edge as circuit-switched voice, i.e. PSTN.
Or This?

• Our company provides call routing intelligence.

Vendor Packet Network

Gateway

CC1

CC2

Corporate IT Server

PSTN

Customer

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In Short -

• Packetized Core allows enhanced customer services.
  – Integration with internet-based services
  – Use of customer db for “call routing”
Vendors: Traditional Telcos

• Major IXCs offer services to accommodate VoIP customers
Remaining Issues –

• Protocol Battle
  – In converged networks, SIP & H.323 struggle for supremacy.
  – Living together yields complexity

• Future of SS7
  – Should it be replaced with IP-based SS8?
Remaining Issues – Addressing

• Need to reconcile the NANP and IP address spaces.
• IETF ENUM working group.
• Simple, in principle.
• Needs more work (NAPTR system, regulatory framework).
• Usual DNS system resolves to IP address, need more service in this case.
Remaining Issues – Access Charges

• Regulatory Fish or Fowl?

• A traditional IXC is an IXC.
  – Regardless of core technology.
  – Pay access charges.

• Is a 100% packet service, like Vonage, an IXC?
  – Should they pay access charges?
  – For now, not viewed as IXC, pay no access charges.
Remaining Issues – Access Charges

• Barrier to change?
  – Reduce LEC incentive to packetize?
  – Eliminate/reduce possibility of LEC-IXC interface becoming packetized.
Remaining Issues –
Regulatory Philosophy / Environment

• Circuits regulated / packets not?
• How do Next Gen telcos contribute to USF?
• Obligation to serve?
Outlook

• PSTN → PTN
  – Public Telephone Network

• PTN made up of multiple companies:
  – Mostly packetized internal nets
    » portions engineered for voice
  – Taking years/decades to phase out circuit switching
Outlook cont...

• PTN companies interact in several standardized ways
  – including traditional circuit protocols
    » at least as long as the analog LL exists
    » as long as competitive/regulatory environment is circuit-switched legacy
  – including IP
    » MGC-MGC communication
    » possibly with SG/MG mediation
CPE

• PBX (as we know it) will be replaced:
  – by Voice Servers
    » SIP: proxies, location servers, etc.
    » H.323: gateways, gatekeepers, etc.
  – by Application Servers
    » Voice Mail, ACD, etc.
    » performing today’s functions with enhancement by new services
PBX

• PBX Notes:
  – PBXs have long lifetimes.
  – Single location SMBs are served very well by traditional circuit-switched systems.
Risks

• Decreasing influence of traditional regulatory methods
  – Loss of Universal Service?
    » Universal service requires that there be a “Carrier of Last Resort” that must serve high-cost, low-profit customers. Who?
      • “Not I,” says the cable company.
      • “Not I,” says the CLEC.
      • “Not I,” says Vonage.
      • “Not I,” says the Next Gen Telco.
      • “Not I,” says the cellular company.
    » ILECs – the Little Red Hens? – are losing local exchange wireline customers in droves.
      • When can they legally terminate service?
Likely Outcome

• Widely varying prices
  – Rural areas hard hit (the term we wanted to use can’t be printed...)

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