Communication Protocols  
and Internet Architectures

Harvard University  
CSCI S-I

Lecture #6 – Frame Relay

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Frame Relay Protocol  
Design and Implementation

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Frame Relay

- Frame relay defines a network interface, not a specific implementation.
- Network architecture is a classic packet switching architecture.
- Frame relay protocol is a much simplified X.25 (which is a thirty year old protocol.)
- Limited call processing, most current implementation use PVCs
- PVCs identified via DLCI, which have local significance only (in most implementations.)
- Switch handles variable length frames at level 2
- Appropriate for both public and private networks.

Typical Frame Relay Network

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Simple Network with Private Line

Three Site Network using Private Lines
SP3 Protocol Framework

- Service
  - The Service defines what the protocol does, not how it is done.
- Purpose
  - The Purpose is the specific functionality, such as flow control, error correction, data transfer, etc., that the protocol provides.
- Packets
  - The Packet layout determines how the various bits and fields within the packet are defined, assembled and used.
- Procedures
  - The Procedures describe the various packet exchanges and the purpose for each exchange.
Frame Relay Frame Layout

Flag (7E)

DLCI (high order bits)  C/R  EA

DLCI  FE  CN  BE  CN  DE  EA

Payload (aka Information or Data Field)
(Variable Length)

FCS (2 bytes)

Flag (7E)

Single Switch Frame Relay Network
(Not very realistic.)

Router Q

Frame Relay Switch

Router R

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Frame Relay Frame Layout

Flag (7E)

DLCI (high order bits)  C/R  EA

DLCI  FE  BE  CN  DE  EA

Payload (aka Information or Data Field)  (Variable Length)

FCS (2 bytes)

Flag (7E)

Frame Relay Performance Issues

- Minimal protocol processing means minimal delay.
- Discard frame if there are any errors, no retransmission at link level
- Limited congestion control via BECN and FECN
- Committed Information Rate provides a clue about available bandwidth but it is not definitive
Frame Relay Performance Issues

- The access rate is the physical link speed
- The CIR is the subscribed (contracted for) throughput
- The Burst Rate is the short term maximum throughput

```
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<th>Time</th>
<th>Actual Throughput</th>
</tr>
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<tbody>
<tr>
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<td>512kbps</td>
</tr>
<tr>
<td></td>
<td>1mbps</td>
</tr>
<tr>
<td></td>
<td>1.5mbps</td>
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<tr>
<td></td>
<td>1mbps</td>
</tr>
<tr>
<td></td>
<td>512kbps</td>
</tr>
</tbody>
</table>
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Frame Relay Congestion Issues

- Committed Information Rate (CIR):
- Forward Explicit Congestion Notification: FECN bit indicates congestion on path to destination.
- Backward Explicit Congestion Notification: BECN bit indicates congestion on reverse path.
- Discard Eligibility Bit provides a clue about what is “best” to discard.
- Use of FECN, BECN and DE implementation specific.
Frame Relay Error Handling

- Frames can be discarded by the network for the following reasons:
  - Bad CRC
  - Protocol error within the frame header
  - CIR exceeded
  - Network congestion
- Frame relay network relies on higher layer protocols in end systems (CPE) to recognize and handle error conditions.

Frame Relay Management

- Local Management Interface (LMI)
  - Keep alive
  - Configuration Status
- Service Provisioning
  - Network map created at subscription time
  - PVCs changed by service provider in "near real time"
  - QOS “hype” versus reality
Typical Frame Relay Service Tariff

- One time installation charges (for access line and frame relay service)
- Monthly access line charge
- Monthly access port charge
- Monthly CIR charge
- Monthly per PVC charges
- Possible usage based burst charges
- Other network management charges
- Service tariff is typically distance insensitive.

Frame Relay Access to the Internet
Frame Relay Services and Market

- Extensive marketing hype has always been a part of the market.
- Frame Relay Forum was very important in creating the market for this service
- Services offered by all major carriers
- Tariff options include both flat rate, usage sensitive and PVC based pricing
- Frame relay demonstrates the classic public versus private network decision for end users
- Frame relay will be replaced in the “next few years.” It is unclear what this really means.

What is the Internet?
A Simple Approach to Understanding its Complexity
What is the Internet

- A network of networks with millions of users
- With large national and international ISPs as the core networks
- With regional ISPs connected to national ISPs
- With local ISPs connected to national/regional ISPs
- All ISPs exchanging inbound and outbound traffic with other ISPs across public and/or private peering points.
- All using the TCP/IP suite of protocols
Internet Trace from Harvard to MIT

fas% traceroute www.mit.edu
traceroute to DANDELION-PATCH.MIT.edu (18.181.0.31), 40 byte packets
1 scmr-gw.fas.harvard.edu (140.247.30.1) 1 ms 1 ms 1 ms
2 sc-gw.fas.harvard.edu (140.247.6.2) 1 ms 1 ms 0 ms
3 camgw1-fas.harvard.edu (140.247.20.1) 1 ms 2 ms 1 ms
4 192.5.66.18 (192.5.66.18) 2 ms 1 ms 1 ms
5 192.5.66.50 (192.5.66.50) 1 ms 1 ms 1 ms
6 192.5.66.41 (192.5.66.41) 1 ms 2 ms 1 ms
7 192.5.66.34 (192.5.66.34) 1 ms 2 ms 1 ms
8 MIT-MEDIAONE.MIT.EDU (18.95.0.1) 30 ms 2 ms 2 ms
9 W20-RTR-FDDI.MIT.EDU (18.168.0.8) 3 ms 3 ms 3 ms
10 DANDELION-PATCH.MIT.EDU (18.181.0.31) 2 ms * 4 ms
fas%

Internet Trace to Oxford University

fas% traceroute www.oxford.edu
traceroute to www.OXFORD.edu (163.1.0.45), 30 hops max, 40 byte packets
1 scmr-gw.fas.harvard.edu (140.247.30.1) 1 ms 1 ms 1 ms
2 sc-gw.fas.harvard.edu (140.247.6.2) 1 ms 1 ms 0 ms
3 camgw1-fas.harvard.edu (140.247.20.1) 1 ms 0 ms 1 ms
4 192.5.66.18 (192.5.66.18) 2 ms 1 ms 1 ms
5 192.5.66.9 (192.5.66.9) 2 ms 2 ms 2 ms
6 12.127.80.125 (12.127.80.125) 3 ms 3 ms 3 ms
7 br2-a3110s1.cb1ma.ip.att.net (12.127.5.10) 3 ms 3 ms 3 ms
8 br3-h20.wswdc.ip.att.net (12.127.15.177) 12 ms 13 ms 11 ms
9 gr1-a3100s1.wswdc.ip.att.net (192.205.31.185) 13 ms 13 ms 13 ms
10 - 15 .... multiple hops in ALTER.NET, only a few shown in this slide
16 - 21 .... multiple hops in Teleglobe.net, only a few shown in this slide
22 external-gw.ja.net (128.86.1.40) 145 ms 145 ms 143 ms
23 london-core.ja.net (146.97.251.58) 152 ms 142 ms 145 ms
24 146.97.251.82 (146.97.251.82) 150 ms 148 ms 149 ms
25 noucs2.backbone.ox.ac.uk (192.76.35.2) 152 ms 155 ms 150 ms
26 wwwtest.ox.ac.uk (163.1.0.45) 152 ms 150 ms 152 ms
fas%
Three Minute Wrap-Up

• Please write down the three or four major points that were discussed during the lecture.
• Note whether the material was presented clearly and/or how it should have been done differently.
• Ask any questions that I should address next time.
• Please do a Wrap-Up at the end of lecture and hand it in as you leave or fill out the form on the web site.
• Do not sign your form. (The form on the web site is also anonymous.)
• Thank you!