Issues Underlying Supporting Multimedia Applications in IEEE 802.1

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Multimedia Applications

Applications involving many types of information

Data			
Audio & Video	Stored		*Training, mail*
	Live	Interactive	*Conferencing*
		Non-interactive	*TV Broadcast*
Still Images		Interactive	*Browsing*
		Non-interactive	*Archiving*

Video Applications

Stored Video Applications

- Training
  - Corporate training rooms, education, factory-floor reference
- Point of sale
  - Information kiosks, product information, advertising
- Video database
  - Advertising agencies, video editing groups, video production companies, karaoke systems, utility companies

Video Applications

Live Video Applications
- Desktop video conferencing
- Computer-supported collaboration
- Network TV

Other Networked Applications Support
- Large storage capacity
  - Databases
  - Home pay-per-view

Traffic Characteristics

	Data Traffic	MM Traffic
Data rate	Low	High
Traffic pattern	Bursty	Stream-oriented Highly bursty
Reliability req.	No Loss	Some loss
Latency req.	None	May be small (e.g., 20msec)

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Traffic Characteristics (cont.)

	Data Traffic	MM Traffic
Mode of communication	Point-to-point	Multipoint
Temporal relationships	None	Synchronized transmissions
Type of service	Single traffic type	Multiple types

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Requirements of Multimedia Applications

- High bandwidth
- Guaranteed bandwidth
- Guaranteed end-to-end latency
- Multicasting

Digital Video Data Rates

- Low quality or talking heads
  - 64 kb/s to 774 kb/s
  - H.261 or low-end MPEG
- Business quality
  - 1 Mb/s to 2.5 Mb/s
  - MPEG, DVI, software codecs, low-end JPEG
- High Quality
  - 3 Mb/s to 8 Mb/s
  - MPEG and JPEG (also TrueMotion)
- Studio quality
  - 10 Mb/s to 45 Mb/s
  - MPEG, JPEG, proprietary

High Bandwidth Requirement

Type	Bandwidth per Stream	20 users
Low end	64 kbps - 384 kbps (teleconferencing)	3 Mbps
Corporate video	1 Mbps - 2 Mbps (training, video mail)	30 Mbps
High quality	3 Mbps - 8 Mbps (presentations, video editing)	100 Mbps
Advanced	8 Mbps - 20 Mbps (advanced professional, HDTV)	2 Gbps

Guaranteed Bandwidth Requirement

- Stream-oriented applications
  - Bandwidth to be available on a continuous basis
- Degree of burstiness depends on
  - encoding scheme / content
  - latency / buffering

Latency Requirement

- Interactive Applications (e.g. videoconferencing)
  - end-to-end delay < 100ms
  - Overhead for encoding/decoding:
    - CBR: 50 - 250 ms
    - VBR: a few ms - 100 ms
- Non-interactive Applications
  - No stringent delay requirement (e.g. broadcast movies)
  - Some delay requirement (e.g. broadcast news)

Latency and buffering are related

Multicasting Requirement

- Many multimedia applications involve multiple participants
- Size of multicast depends on applications
  - Videoconferencing (3-4 participants, many-to-many)
  - group meeting (10's of participants, one-to-many)
  - video broadcasting (100's of participants, one-to-many)

Use of Ethernets for Multimedia Applications

- Ethernet does not
  - provide bounded delays
  - distinguish between different traffic types
- However, it is one of the most widely deployed LAN schemes today.

How well can Ethernets support multimedia communications?

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Video on Ethernet

Dmax (ms)	Lmax	V=64kb/s		V=384kb/s		V=1536kb/s	
		Nmax	N.U.	Nmax	N.U.	Nmax	N.U.
20	0.001	55	35%	14	54%	4	61%
20	0.01	64	41%	17	65%	5	77%
100	0.001	89	57%	18	69%	5	77%
100	0.01	104	67%	20	77%	5	77%
Bandwidth Limit		156		26		6	

Dmax: Maximum tolerable delay
Lmax: Maximum tolerable packet loss rate
V : Video stream bandwidth
Nmax: Maximum number of streams that can be supported while meeting the delay and loss constraints
N.U.: Network utilization

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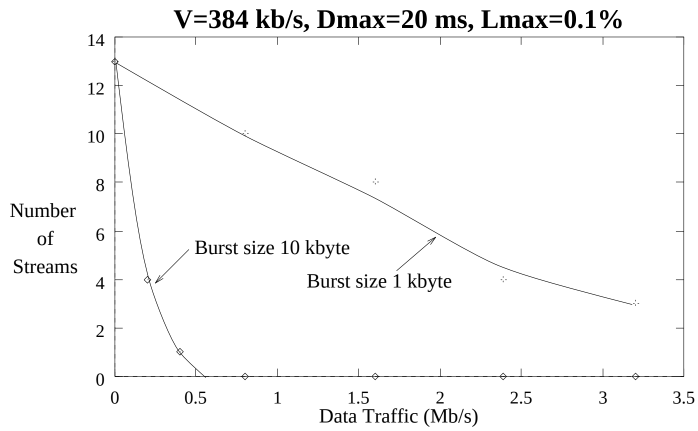
Integrated Services on Ethernet



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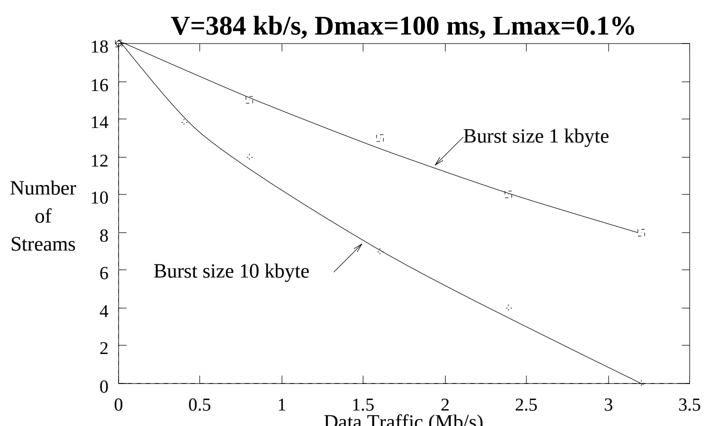
Integrated Services on Ethernet



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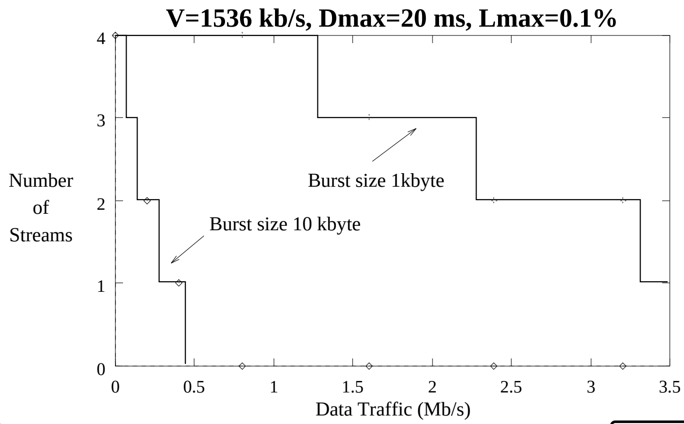
Integrated Services on Ethernet



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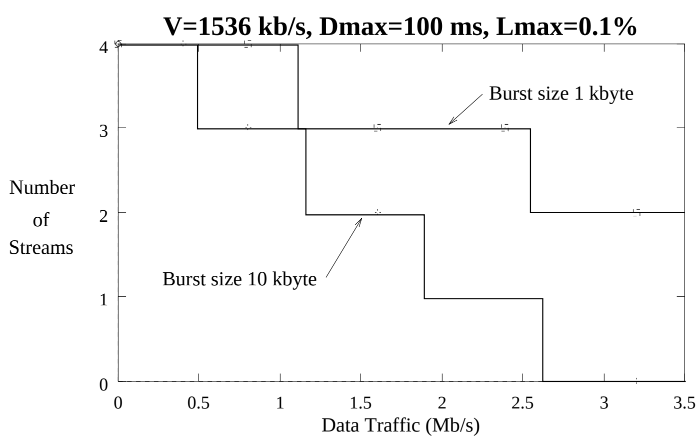

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100Base-T Performance

Number of Streams Supportable

		10Base-T						100Base-T			
		V=64kb/s		V=384kb/s		V=1536kb/s		V=384kb/s		V=1536kb/s	
Dmax (ms)	Lmax	Nmax	N.U.	Nmax	N.U.	Nmax	N.U.	Nmax	N.U.	Nmax	N.U.
20	0.001	55	35%	14	54%	4	61%	138	53%	43	66%
20	0.01	64	41%	17	65%	5	77%	160	61%	49	75%
100	0.001	89	57%	18	69%	5	77%	180	69%	49	75%
100	0.01	104	67%	20	77%	5	77%	205	79%	52	80%
Bandwidth Limit		156		26		6		260		65	

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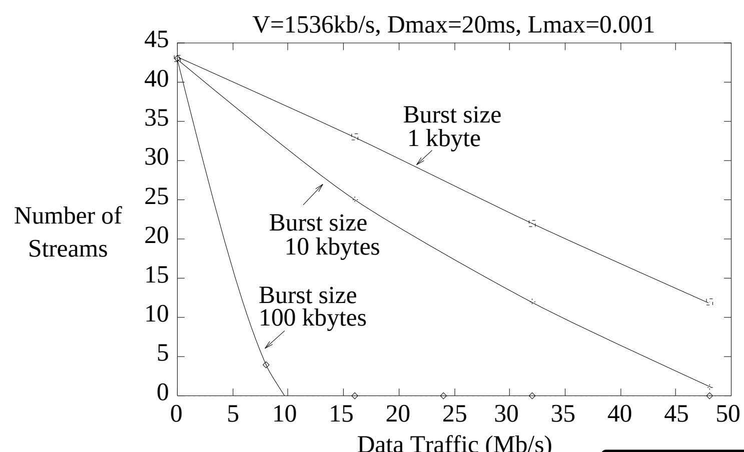
100Base-T Performance

Integrated Video and Data Services



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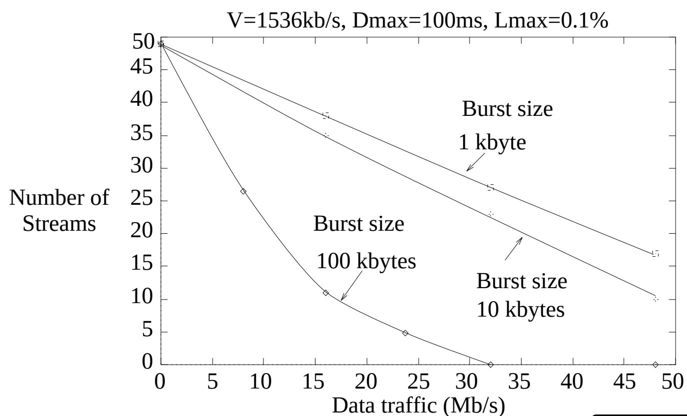
100Base-T Performance

Integrated Video and Data Services



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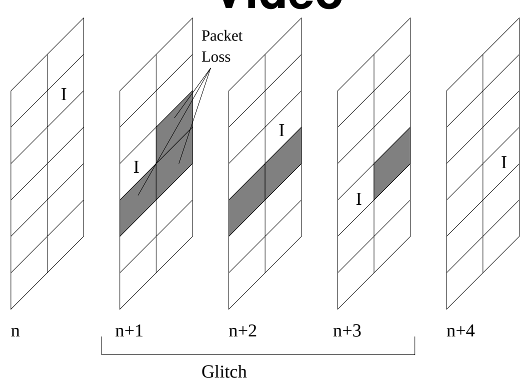
Packet Loss Causes Glitches in Video



- The effect of packet loss may persist multiple frames, depending on interdependency among frames
- Multiple packets may contribute to the same glitch

  ==> packet loss rate is not an accurate measure of network performance

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Evaluation of Ethernets Carrying Video Traffic

- 10Base-T and 100Base-T segments simulated
- Real video sequences used
- CBR video, H.261 encoding
- End-to-end delays taken into account
- Dependence among frames taken into account; network performance measured in terms of glitches
- 2 packetization schemes considered:
  - Constant Size and Rate Packetization (CSRP)
  - Variable Size and Rate Packetization (VSRP)
- Effect of bursty and non-bursty data traffic on video examined

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Video on a 10Base-T Segment

D_{max} (ms)	g_{max} (per min.)	N_{max} (susie) 384 kb/s	N_{max} (susie) 1536 kb/s	N_{max} (miss america) 384 kb/s	N_{max} (miss america) 1536 kb/s	N_{max} (table tennis) 384 kb/s	N_{max} (table tennis) 1536 kb/s
20	0.1	0	0	0	0	0	0
	1	0	0	0	0	0	0
60	0.1	11 (42%)	4 (61%)	11 (42%)	4 (61 %)	6 (23%)	2 (30%)
	1	13 (50%)	5 (77%)	13 (50%)	5 (77%)	10 (38%)	3 (46%)
100	0.1	13 (50%)	5 (77%)	13 (50%)	5 (77%)	12 (46%)	4 (61%)
	1	17 (65%)	5 (77%)	17 (65%)	5 (77%)	17 (65%)	5 (77%)
250	0.1	18 (69%)	5 (77%)	18 (69%)	5 (77%)	17 (65%)	5 (77%)
	1	20 (77%)	5 (77%)	20 (77%)	5 (77%)	19 (73%)	5 (77%)
500	0.1	19 (73%)	5 (77%)	19 (73%)	5 (77%)	19 (73%)	5 (77%)
	1	20 (77%)	5 (77%)	20 (77%)	5 (77%)	20 (73%)	5 (77%)
Bandwidth limit		26	6	26	6	26	6

Maximum number of streams supportable for CSRP (B/V=50 ms)

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Video on a 10Base-T Segment

D_{max} (ms)	g_{max} (per min.)	N_{max} (susie) 384 kb/s	1536 kb/s	N_{max} (miss america) 384 kb/s	1536 kb/s	N_{max} (table tennis) 384 kb/s	1536 kb/s
20	0.1	9 (36%)	4 (61%)	9 (36%)	4 (61 %)	8 (31%)	4 (61%)
	1	12 (46%)	4 (61%)	12 (46%)	4 (61%)	12 (46%)	4 (61%)
60	0.1	14 (54%)	4 (61%)	14 (54%)	4 (61 %)	14 (54%)	4 (61%)
	1	16 (61%)	5 (77%)	16 (61%)	5 (77%)	16 (61%)	5 (77%)
100	0.1	15 (58%)	5 (77%)	15 (58%)	5 (77%)	15 (58%)	5 (77%)
	1	18 (69%)	5 (77%)	18 (69%)	5 (77%)	18 (69%)	5 (77%)
250	0.1	19 (73%)	5 (77%)	19 (73%)	5 (77%)	19 (73%)	5 (77%)
	1	20 (77%)	5 (77%)	20 (77%)	5 (77%)	20 (77%)	5 (77%)
500	0.1	19 (73%)	5 (77%)	19 (73%)	5 (77%)	19 (73%)	5 (77%)
	1	20 (77%)	5 (77%)	20 (77%)	5 (77%)	20 (77%)	5 (77%)
Bandwidth limit		26	6	26	6	26	6

Maximum number of streams supportable for VSRP (B/V=50 ms)

Video on a 100Base-T Segment

D_{max} (ms)	g_{max} (per min.)	N_{max} (susie) 384 kb/s	1536 kb/s	N_{max} (miss america) 384 kb/s	1536 kb/s	N_{max} (table tennis) 384 kb/s	1536 kb/s
20	0.1	0	0	0	0	0	0
	1	0	0	0	0	0	0
60	0.1	140 (54%)	40 (61%)	141 (54%)	40 (6 1%)	136 (52%)	38 (58%)
	1	151 (58%)	42 (65%)	151 (58%)	42 (65%)	145 (56%)	41 (67%)
100	0.1	168 (65%)	42 (65%)	168 (65%)	42 (65%)	168 (65%)	42 (65%)
	1	185 (71%)	47 (72%)	185 (71%)	47 (72%)	185 (71%)	47 (72%)
250	0.1	168 (65%)	42 (65%)	168 (65%)	42 (65%)	168 (65%)	42 (65%)
	1	185 (71%)	47 (72%)	185 (71%)	47 (72%)	185 (71%)	47 (72%)
Bandwidth limit		260	65	260	65	260	65

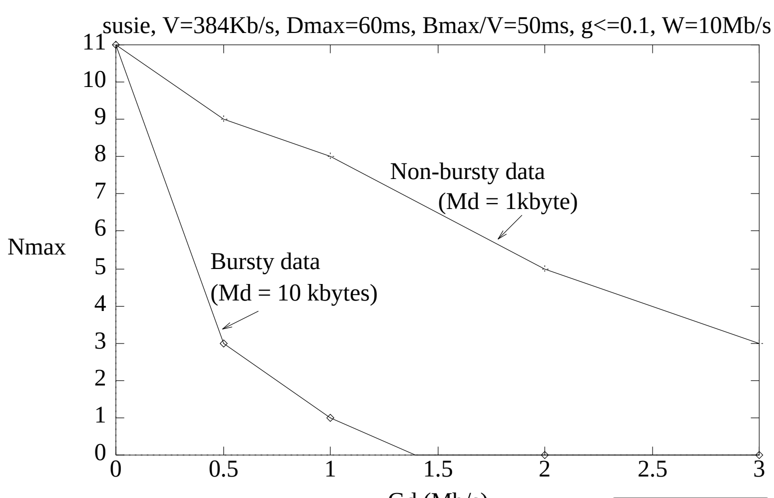
Maximum number of streams supportable for CSRP (B/V=50 ms)

Video on a 100Base-T Segment

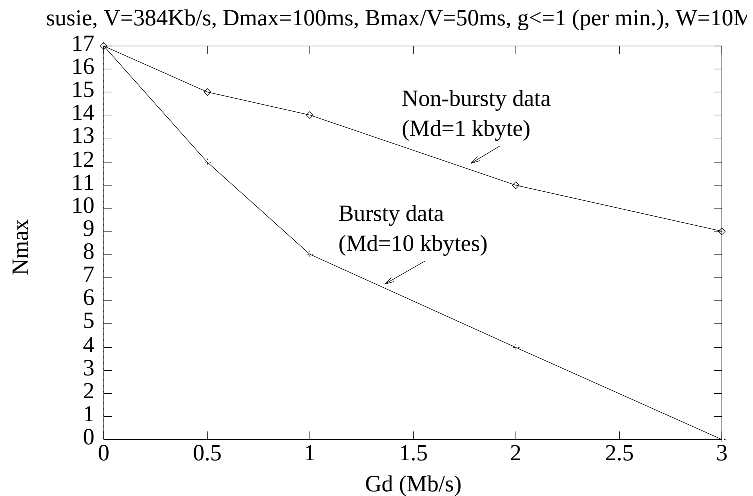
D_{max} (ms)	g_{max} (per min.)	N_{max} (susie) 384 kb/s	N_{max} (susie) 1536 kb/s	N_{max} (miss america) 384 kb/s	N_{max} (miss america) 1536 kb/s	N_{max} (table tennis) 384 kb/s	N_{max} (table tennis) 1536 kb/s
20	0.1	118 (45%)	31 (47%)	118 (45%)	31 (4 7%)	115 (44%)	30 (46%)
	1	135 (52%)	35 (54%)	135 (52%)	35 (54%)	134 (51%)	35 (54%)
60	0.1	167 (64%)	42 (65%)	167 (64%)	42 (65%)	167 (64%)	42 (65%)
	1	186 (71%)	46 (71%)	186 (71%)	46 (71%)	186 (71%)	46 (71%)
100	0.1	172 (66%)	43 (66%)	172 (66%)	43 (66%)	172 (66%)	43 (66%)
	1	190 (73%)	48 (74%)	190 (73%)	48 (74%)	190 (73%)	48 (74%)
250	0.1	172 (66%)	43 (66%)	172 (66%)	43 (66%)	172 (66%)	43 (66%)
	1	190 (73%)	48 (74%)	190 (73%)	48 (74%)	190 (73%)	48 (74%)
Bandwidth limit		260	65	260	65	260	65

Maximum number of streams supportable for VSRP (B/V=50 ms)

Integrated Services: 10Base-T



Integrated Services: 10Base-T



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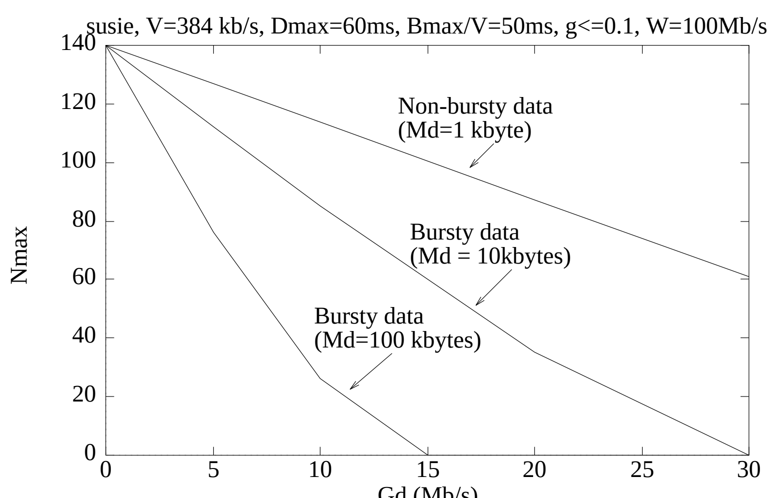
Integrated Services: 100Base-T



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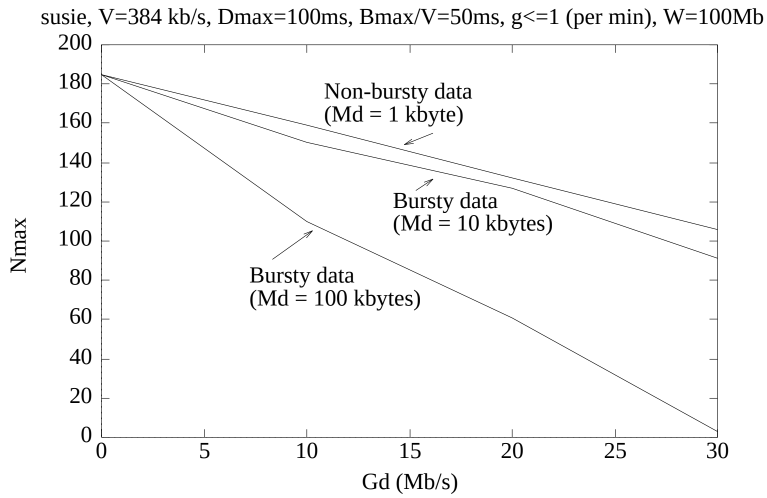
Integrated Services: 100Base-T



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Today's IEEE 802.1

- Single Spanning Tree
  - Avoids broadcast / multicast loops
  - Multiple copies with unicast

  Limited efficiency
- Transparent Bridging
  - Stations relocation without registration: "Learning bridges"
- Multicast via Broadcast
  - Multicast traffic assumed to be low
  - Simplicity & transparency

  handled via broadcast
- MIB

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Media Access Control Protocols

- Guaranteeing bandwidth on a continuous basis
- Meeting latency constraints (100 ms or less)
- Integrated services
  - IEEE 802.3 (Ethernet)
    - Contention-based, no priority function
  - IEEE 802.5 (Token-Ring)
    - Priority function available
  - FDDI (ANSI X3T9.5)
    - Support for synchronous traffic
  - Iso-Ethernet (IBM/National)
    - Support for isochronous traffic

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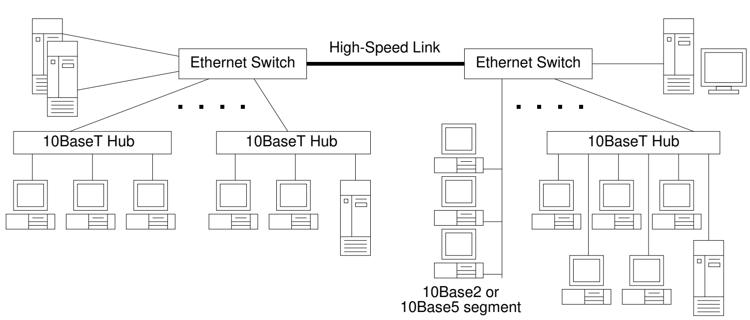
Implications of High Bandwidth Requirement

High Bandwidth ⇨ Switching Hubs

Interconnected Switching Hubs ⇨ Large-sized subnet



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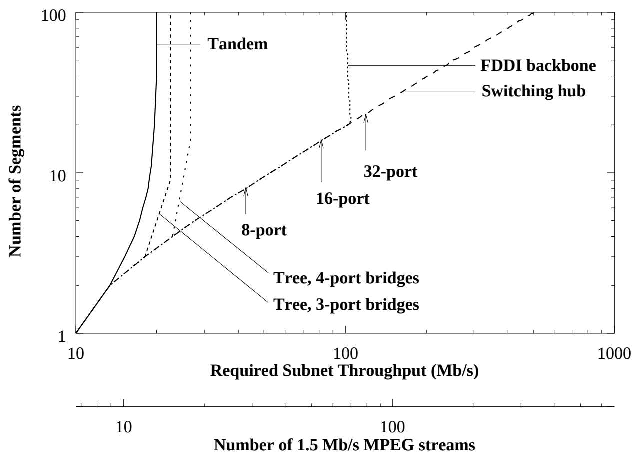
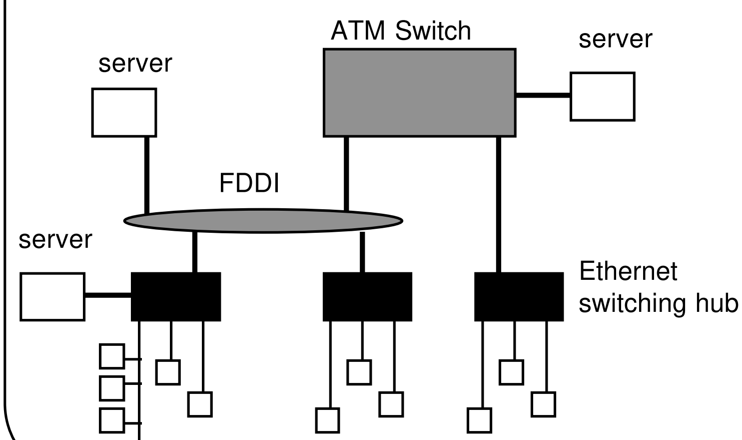
Limits on Subnetwork Throughput



Possible Campus Network Infrastructure



Implications of Large-Sized Subnets

- Large number of addresses stored in bridge tables
- Deployment of stations on the ports: avoidance of bottlenecks

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Implications of Guaranteed Bandwidth and Latency

Guaranteed BW & Latency ⇨ Admission Control

Admission Control: No more sessions are permitted on a given resource (e.g. an Ethernet segment) than it can accommodate

- Requires knowledge in users' locations, current sessions, and aggregate bandwidth
- Needs to work with multicast

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Implications of Guaranteed Bandwidth and Latency (cont.)

- Reservation needs to be done end-to-end for overall effectiveness
- Switches mostly do not have the capacity to support the management necessary to guarantee bandwidth due to wire-speed requirement
- Admission control by itself cannot guarantee bandwidth

==> A simpler mechanism to provide more predictable behavior as traffic increases?

Implications of Guaranteed Bandwidth and Latency (cont.)

Guaranteed BW & Latency ⇨ Traffic Types Differentiation

- Data traffic cannot have admission control
  - must be prevented from affecting video traffic (prioritization?)

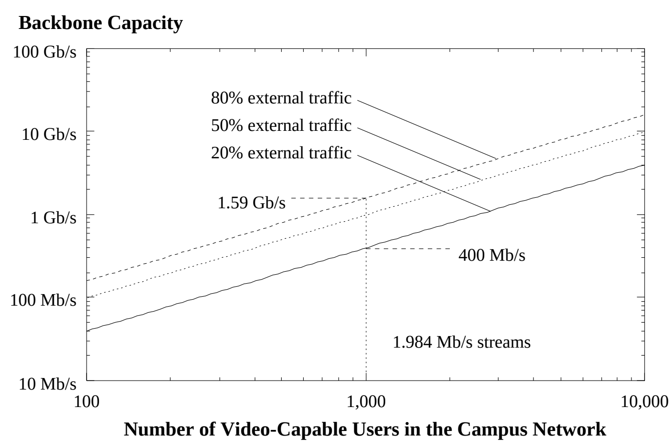
Multicasting of Video / Audio Streams Must Be Done Efficiently

Example:

- An Ethernet switch
  - 128 ports
  - 1.28 Gb/s aggregate throughput (hence non-blocking)
- 4 mulitcast video streams
  - 2 Mb/s each → 8 Mb/s total

If broadcasting is used, the whole network bandwidth is taken

Example of Required Backbone Bandwidth



Implications of Multicasting Requirement

Efficient multicasting of video traffic

Registration over multiple hops

Traffic-type differentiation
(data traffic must be handled using existing scheme)

Conclusions

- Admission Control
  - MIBs must be defined to identify network resources, keep track of sessions, etc.
- Filtering
  - Explicit requests
  - Propagation of information in a multi-switch environment
- Traffic Types Differentiation
  - Based on ? (addresses?)
- Single Spanning Tree
  - Multiple spanning trees?