Introduction

Perhaps easier to do the why before the how

Gigabit Ethernet — a very quick introduction
Ever increasing requirements & user expectations
The Future
LAN, Campus, MAN, WAN, The world
10 Gigabit Ethernet
The Future

Operational stability
Product examples
Ease of integration
Success expansion
Does it work? Yes!

Our experiences
Before and after
Does it work? Yes!
Ease of integration
Product examples
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Gigabit Ethernet — a very quick introduction

Our experiences
Before and after
Ease of integration
Product examples
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Success expansion


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Imperial College, London
Networked Systems Architect
Stuart McRobert

Migration to Gigabit Ethernet — How? and Why?
Fast Ethernet to the desktop the desired norm

- Low cost of 10/100 UTP Ethernet NICs
- Lower costs, faster systems, happier users
- Plenty of memory and local disk space
- IO capability enhanced
- Always faster CPUs
- Significant performance improvements

User’s Desktops and Laptops

- New products
- Higher expectations
- Change in network profile, the Web
- Lower costs
- Especially at the desktop
- Increase in CPU power
- Increase in network traffic

Background
Changing Traffic Profiles

Only a few years ago, Client Server traffic dominated the LAN. For example, lots of local NFS traffic from Small low power systems, perhaps diskless.

The 80/20 rule, about 80% of the traffic local.

Today, The 80/20 rule, about 80% of the traffic local.

Small low power systems, perhaps diskless.

For example, lots of local NFS traffic.

Client Server traffic dominated the LAN. Only a few years ago.

Collisions supposed to be a rarity not the norm!

Core networks still 10 Mbit/s shared Ethernet?

Central services, (much) slower to change

May buy themselves a local (cheap) switch

Desire for faster networking

Faster systems, desktop and/or laptop

Users quick to upgrade their own systems

Work Groups

Coupled with high power user systems, the way people work

The WWW has significantly changed traffic
The Problem

- Traffic volumes, significant increase & rising
- More faster power users
- Web traffic is graphical — so much more data
- Relatively long download times vs data life of maybe just a few seconds, until the next click
- Web traffic is graphical — so much more data
- More faster power users
- Traffic volumes, significant increase & rising

Your Problem

- Slow overloaded local networks?
- Users blame poor networking for everything
- Need to improve the network
- Keep disruption to a minimum
- From Not me first! to Please upgrade me
- Need to improve the network
- So convenient, but hard to prove otherwise
- Keep planning to a minimum
- Plan Plan and Plan again
- Try it first, make sure it does what you think
- Web caches help
- Outside the local workgroup, Internet, Internet
- Traffic is no longer just local
- Maybe just a few seconds, until the next click
- Relatively long download times vs data life of
- Web traffic is graphical

The Problem
Software still has an important role to play

- Introduce new products and possible enhancements
- Cost reductions with performance
- ASICs for both, all at true wire speed
- ASICs for wire speed IP routing
- ASICs for wire speed switching

Lot of work can now be done in hardware

Hardware Advances

Hardware Advances

Remember the golden rule — keep it simple

- Moderately complex solution
- Small number of VLANs
- One (perhaps 2) dedicated routers on a stick
- Unless you want ATM performance to the desktop?
- ATM at the core
- Ethernet at the edge
- Only just over a year ago probably consider
Newer Solutions

Ethernet, Fast Ethernet, Gigabit Ethernet

All one happy family of Ethernet

Wire speed switching

Delivers true network bandwidth

All one happy family of Ethernet

Ethernet, Fast Ethernet, Gigabit Ethernet

Wire speed IP routing

Delivers true network bandwidth

Wire speed switching

Can now deliver low latency wire speed

IP Routing can now be fast, efficient, & plentiful
Evolution without revolution

- Shift away from shared to dedicated media
- Full Duplex Ethernet, since no longer a shared medium
- Can do away with CSMA/CD controls
- Shift towards dedicated bandwidth
- From shared coaxial cable to star wiring with a dedicated cable for each device, e.g. 10 BASE-T
- Based on success of Ethernet, builds on
- Evolution without Revolution

Gigabit Ethernet Overview

- Media independence, e.g. Copper and Fiber
- Fast Ethernet over UTP
- Automatic Link Configuration, first seen with 10 BASE-T
- Reduces costs, use less memory speeds
- Allowing switches to avoid unnecessary packet loss when buffers run low, more likely at higher speeds
- Ethernet Flow Control, provides explicit Flow Control
Gigabit Ethernet Overview

- It is Ethernet, just much faster
- Compatible with existing 10/100 Mbps Ethernet
- Hence half duplex support had to be defined
- Collisions and their detection
- Physics of the problem
- Keep it standard
- Full duplex, point to point dedicated links, easy

Overview

Physical Layer

Standards Summary

Switch features, VLANs, Tags, QoS, Redundant Links

Configuration and management

Summary
Physical Layer

- Cover key items, fairly high level
- Things to know about various fiber types and link distances
- Fiber optics and copper cables
- Cover key items, fairly high level
- Things to know about various fiber types and link distances
- Fiber optics and copper cables
- 1,062.5 Gbaud to 2.50 Gb/s speed increase

Standards for Physical Mediums

- IEEE 802.3ab copper to the desktop
- 1000 BASE-CX fairly short distance copper
- 1000 BASE-LX single-mode fiber backbone
- 1000 BASE-LX multi-mode fiber backbone
- 1000 BASE-SX multi-mode fiber horizontal
- IEEE 802.3z covers support for 1,000 BASE-X adapted Fiber Channel
- Various fiber types and link distances
- Cover key items, fairly high level
- Fiber optics and copper cables
- Physical Layer
<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>µm</th>
<th>Bandwidth (MHz.km)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SX MMF</td>
<td>50</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>SX MMF</td>
<td>50</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>SX MMF</td>
<td>62.5</td>
<td>160</td>
<td>220</td>
</tr>
<tr>
<td>SX MMF</td>
<td>62.5</td>
<td>200</td>
<td>275</td>
</tr>
<tr>
<td>SX SMF</td>
<td>8-10</td>
<td>5000</td>
<td>550</td>
</tr>
</tbody>
</table>

0 fiber link lengths
1000 BASE-SX

- Typically 850 nm (770-860) visible light
- Cost effective, most often used in the LAN
- Gigabit speeds require lasers not LEDs
- SX — Short Wavelength Light

1000 BASE-LX

- 1300 nm (1270-1355) infrared light
- Primarily used with single mode fiber, but can also be used with multi mode fiber too
- Works over various grades of fiber optics
- 50 µm and 62.5 µm MMF, also 10 µm SMF
- From long distance telecommunications lasers
- Longer distances, e.g. cross campus

1000 BASE-TX

- Often use MMF in the LAN
- Really designed to work with what we have
- 50 µm and 62.5 µm MMF only
- Works over various grades of fiber optics
- Gigabit speeds require lasers not LEDs
- SX — Short Wavelength Light
Fiber Optic Connectors

Standard specifies one optical-fiber connector

- Duplex SC
- Very common and also used for 100BASE-FX

Industry would like something

- Half the size of the SC, about RJ45 size
- Cheaper, yet still high performance
- Half the size of the SC, about RJ45 size
- Industry would like something
- Very common and also used for 100BASE-FX
- Duplex SC
- Standard specifies one optical-fiber connector

Products already announced, many early 2000

- 1000BASE-T
- Ethernet 1Gbps, June 1999
- Full and half duplex supported
- 250 Mbps per pair
- Bi-directional transmission over all 4 pairs
- Bi-directional transmission over all 4 pairs
- 250 Mbps per pair
- 4 pairs of UTP Category 5 cable to 100m
- Copper to the desktop

There are other competing products, e.g., from 3M

- The new MT-RJ connector, multi-vendor support
GiGabit Ethernet Top

I

Overview
Physical Layer
Standards Summary
Switch features, VLANs, Tags, QoS, Redundant Links
Configuration and management
Summary

Standards Summary

802.3ae Future 10-Gigabit Ethernet
802.3ad Link Aggregation and Trunking
802.3ac Priority and VLAN Tagging
802.3ab Gigabit over UTP 1000 BASE-T
802.3z Gigabit Ethernet
1000 BASE-LX, SX, CX
802.3x Full duplex & link based flow control
802.3 Ethernet
802.3ae 10-Gigabit Ethernet!

Summary
Configuration and management
Redundant Links
Switch features, VLANs, Tags, QoS,
Standards Summary
Physical Layer
Overview
or even claimed, e.g.

- Wire speed forwarding not always delivered
- May use common chip set, memory helps
- ASICs
  - Application Specific Integrated Circuits —
  - Price, marketing, advances in technology
  - Terms like workgroup switch, core switch
- Important — not all switches are equal
- Move from shared to dedicated LANS

Switches

Summary
- Configuration and management
- Redundant Links
- Switch features, VLANs, Tags, QoS
- Standards Summary
- Physical Layer
- Overview
### Managed 8 Port Switch

<table>
<thead>
<tr>
<th>Source: IT Week Labs, IT Week, 24 August 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>80% Load</td>
</tr>
<tr>
<td>64 256 1518 Bytes</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>64 256 1518 Bytes</td>
</tr>
<tr>
<td>100% Load</td>
</tr>
</tbody>
</table>

Dropped Frames

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### Unmanaged 8 Port Switch

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</tbody>
</table>

Dropped Frames

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Performance

Unmanaged switches

- Generally performed worse than managed
- But usually cheaper
- Select with care
- Big impact on network performance
- Cost not always a good guide
- Seek a few independent benchmark results

Cost not always a good guide

Select with care

But usually cheaper

Generally performed worse than managed

Unmanaged switches

1998

Layer 3 Switches — Ready to Route October

Business Communications Review

Included by permission of BCR
http://www.bcr.com/bcrmag/10/0ct98p34.html

Price Performance
A virtual LAN (VLAN) is a logical grouping of devices, rather than a physical one, based on network topology.
Virtual LANs — Protocol based — single device can be a member of multiple VLANs depending on the protocol used, e.g., IP, IPX, AppleTalk, etc.

Some switches support multiple VLAN types:
- Standard
- Early to market products may be non-
- Standard brings interoperability
- Need for tagging, but a very flexible solution
- Media
- Multiple LANs over the same piece of media
- Like to use VLANs with IP subnets

Virtual LANs —

*Up links
*Port based, plus 802.1Q tagging on Gigabit
*IP networking with each subnet as a VLAN
*Switches often support one or more of these methods
*Protocol used, e.g., IP, IPX, AppleTalk, etc.
*Member of multiple VLANs depending on the protocol based — single device can be a member of multiple VLANs depending on the protocol used, e.g., IP, IPX, AppleTalk, etc.
VLAN Creation, deletion and configuration

Configuration fields include:
- Name
- Tag ID
- IP address
- Ports
- QoS
- Spanning Tree
- Packet filtering

Packet filtering allows for the selection of specific Ethernet packet types into the VLAN.
Ethernet packets can be:

- Untagged — Just as normal
- Tagged — Extra 802.1Q tag included

Allows multiple LANs e.g. IP subnets to travel together over the same physical link

Protect your earlier investment, but fast moving

Pre-standard tagging and VLANs

Again switches supporting multiple types exist
Two sub-nets with corresponding VLANs

- Assign tag number to each VLAN
- Gigabit uplink carries both sub-nets, using tagged ports
- Traffic stays within its own VLAN just as if on its own physical cable
- Some Gigabit Ethernet switches provide QoS
  - e.g. Policy based Quality of Service
  - WFG (Weighted Fair Queuing), etc
  - TCP window manipulation
  - Token Ring
  - SBN (subnet bandwidth manager)
  - ATM
  - RSVP (resource reservation protocol)
  - Frame Relay
  - IP precedence (type of service bits)
  - RSVP
  - 802.1P priority tag
  - CBQ (class based queuing)

Many QoS standards and solutions exist:

- Many QoS standards and solutions exist:
  - 802.1P priority tag
  - CBQ (class based queuing)

Example

<table>
<thead>
<tr>
<th>net</th>
<th>tag</th>
<th>VLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>5xxx</td>
<td>5</td>
<td>5-net</td>
</tr>
<tr>
<td>5-qtagged ports</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gigabit uplink carries both sub-nets, using

<table>
<thead>
<tr>
<th>net</th>
<th>tag</th>
<th>VLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>8xxx</td>
<td>8</td>
<td>8-net</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>net</th>
<th>tag</th>
<th>VLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.128.xxx</td>
<td>8-net</td>
<td>8-qtagged ports</td>
</tr>
</tbody>
</table>

Example
Explicit and Implicit QoS

**Explicit QoS**
- End-station initiated
- Require application changes
- IEEE 802.1p/Q, IETF's RSVP
- Applications control

**Implicit QoS**
- No changes to end-station applications
- Policies centrally set by the network manager
- Network manager controls

Traffic Groups

- Physical port
- 802.1p or 802.1Q MAC address
- VLAN/Subnet or IP address
- Protocol/1P, IPX, SNA, RSVP flow (well-known port numbers)
- TC/UDP session

QoS Profiles

- Policy = Traffic Group + QoS Profile

Policy-Based Quality of Service

QoS — Quality of Service

ATM has extensive QoS been developed over time

Some Gigabit Ethernet switches offer QoS

Can be useful for, e.g., video streams or sound traffic, desire low latency and avoid disturbance from other less time critical traffic, e.g. the WWW.

Generally not as extensive

Example from Extreme Networks Summit

4 QoS profiles handled in the hardware switch

Set minimum and maximum bandwidth for each profile

Protocol filtering can apply to VLAN membership

Each VLAN placed into a profile

Low, normal, medium, high priority

QoS — Quality of Service
Very easy to configure and use if required

- Minimum & maximum bandwidth per VLAN
- Four profiles available on this switch
- Supported in the hardware design

**QoS Configuration**

- Low
- High

**QoS Policy Table**

<table>
<thead>
<tr>
<th>Policy</th>
<th>Low Bandwidth</th>
<th>High Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile 1</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Profile 2</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Profile 3</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Profile 4</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Supported in the Hardware Design**

Redundant Gigabit links

- Some switches support redundant links
- Should the main link fail, it automatically changes over to the backup link
- Often labelled as e.g. port 1 and 1R
- But only one port ever works at any single time
- Changeover in typically less than a second
- Automatically changes over to the backup link
- Should the main link fail
- Some switches support redundant links
- Much better than Spanning Tree (avoid)

Redundant Link Example
Redundant Link Example

Reduces the number of redundant links required back to the central core switch.
Command Line Interface

- v Kinds of important to your network and users
- v Make backups of your switch configurations
- v Upload
- v Download configurations
- v Cut and paste generated configuration
- v Scripting

Complexity — how convenient is it to use?

- v Command history and editing
- v Debug switch configuration
- v Online help
- v Telnet

- v Out of band access, useful when it all goes...
- v Console serial ports
Command Line Interface

- Very easy to use
- Command completion via tab key
- Option prompting and extensive online help
- Command completion via tab key
- Very easy to use

Example, show port configuration