Enterprise Networks:

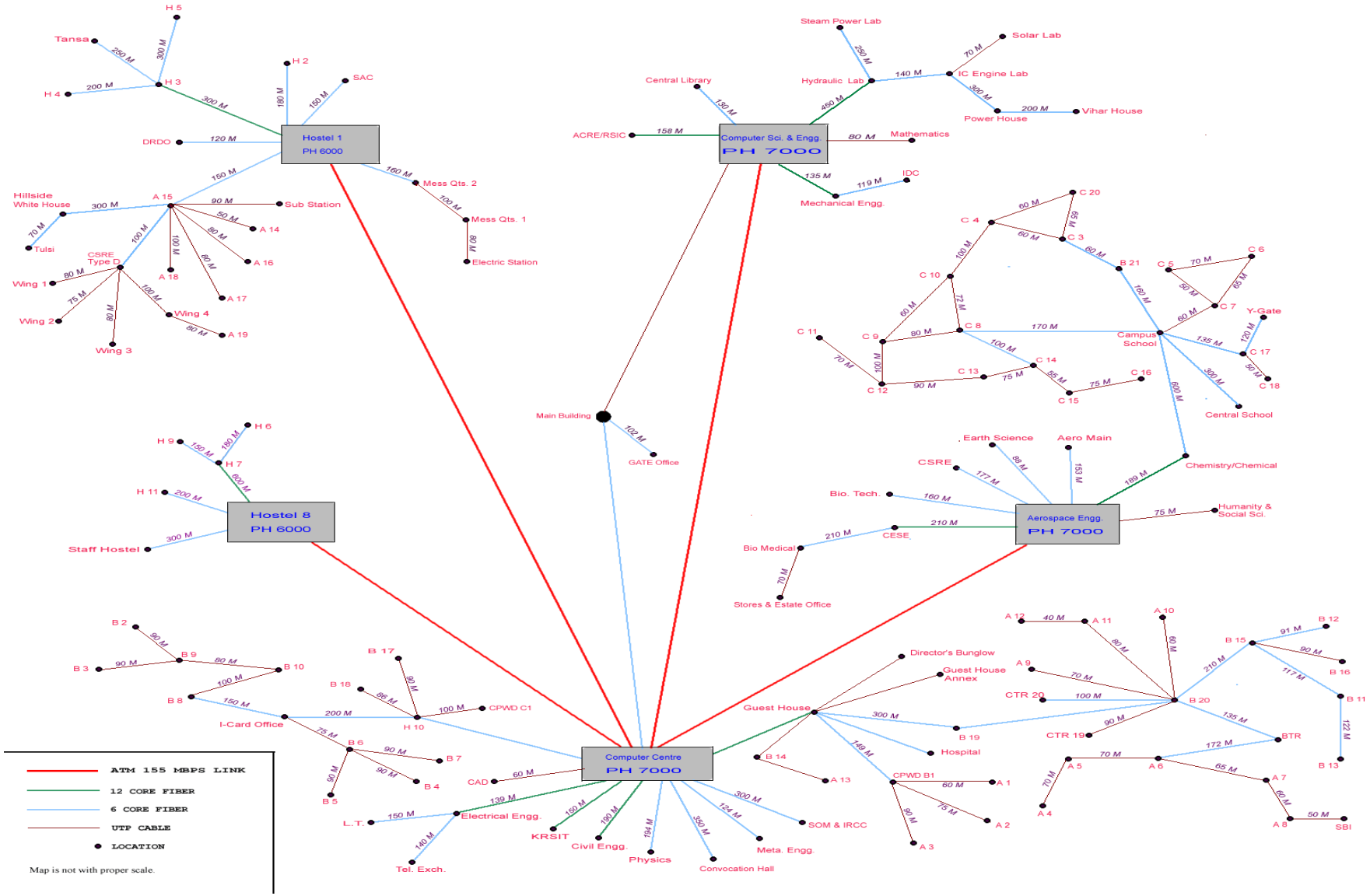
A ‘nano’ to a ‘giga’ perspective

Sridhar Iyer

IIT Bombay

www.it.iitb.ac.in/~sri

What are Enterprise Networks?



What are Enterprise Networks?

- Support thousands of users across a company's diverse geographical locations
  - May involve hundreds of servers
- Each location may look like a simple system, but the complexity increases as these systems are linked together
- Is the Internet an Enterprise Network?

Enterprise Networks: One definition

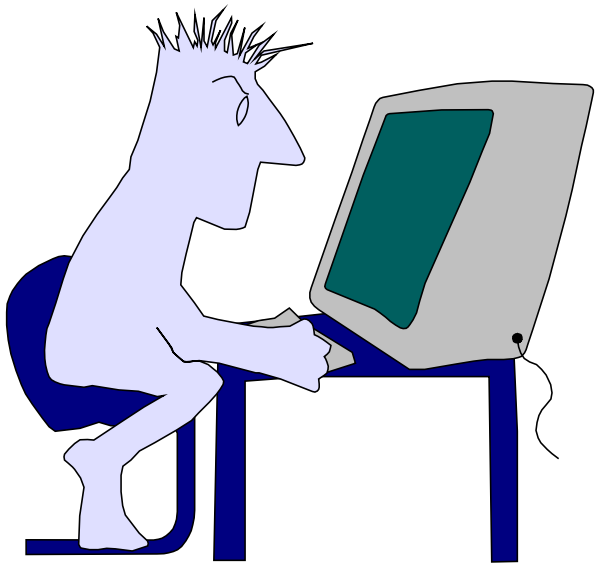
- Large
  - 10^5 edge devices, 10^3 network devices
- Geographically distributed
  - Multiple continents, 10^2 countries
- Tightly controlled
  - IT department has (nearly) complete control over user desktops and network connected equipment

Driving force - Convergence

- Not about gadgets or access technologies
  - These are actually increasing in diversity
- But about *services* and *applications*
  - The quest for Anytime, Anywhere, Anyform access to any intranet/extranet application

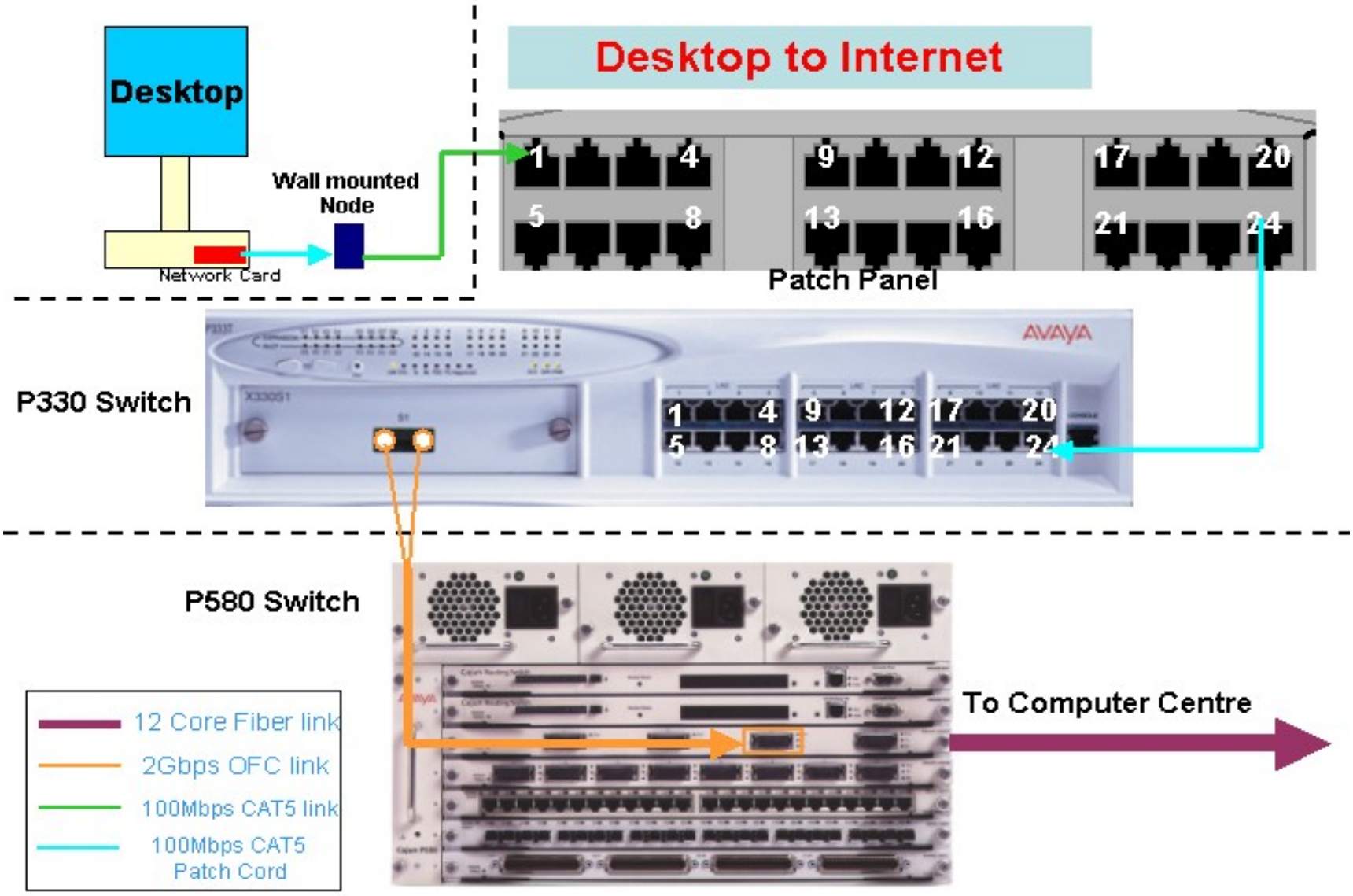
- Enterprises need to cope with demand for new services and applications
  - Supported by computing and communications fabrics
- We need to understand the issues involved
  - A good way to begin: From the ‘nano’ to the ‘giga’ view

A ‘nano’ level view



- A single machine in an organization
  - Smallest component
  - Ex:- A student in KReSIT
- Hardware: Desktop/Laptop
- Software: Application pkgs
- Typical IT spending
  - Around Rs. 50,000/-
  - Upgrade every 2 years?
  - Internet access?

Behind the scenes



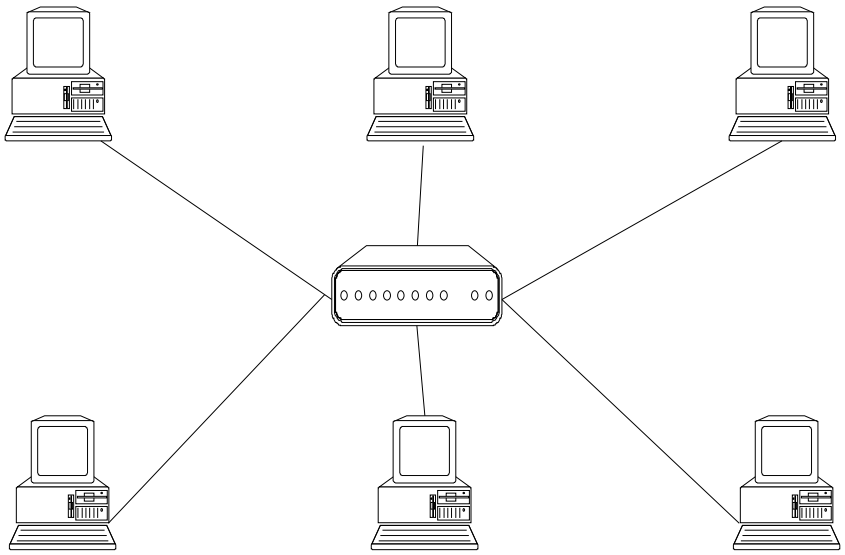
Issues at the ‘nano’ level

- Application-related
  - Software version incompatibilities
    - “This program was working fine yesterday.”
  - Performance
    - “This is way too slow. I need a faster machine.”

- Network-related
  - Security
    - “It looks like there is a virus on my machine.”
  - Administration
    - “I cannot remember which gateway I am supposed to use.”

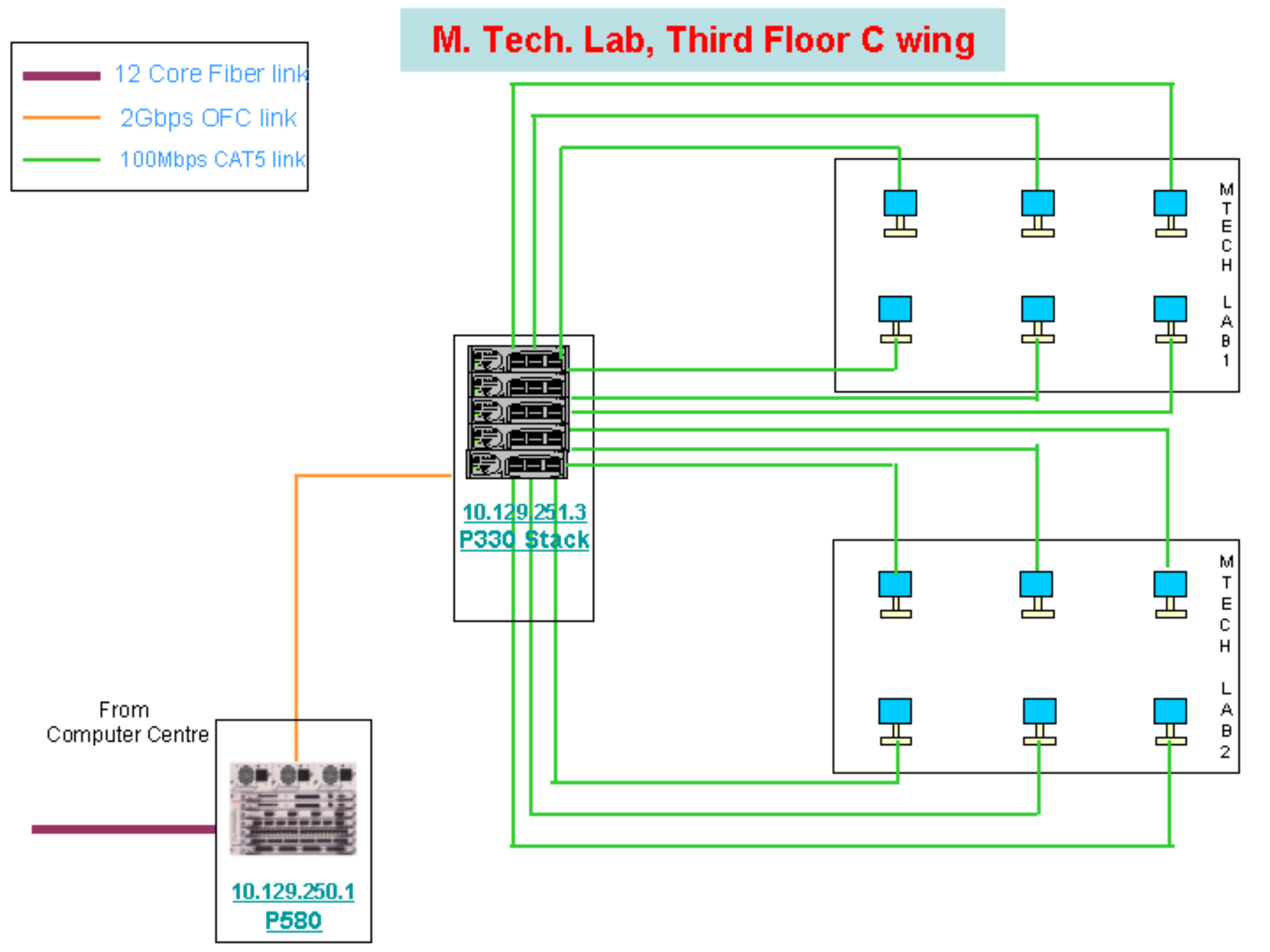
- One solution strategy
  - Rudimentary system administration: Move up one level

A ‘micro’ level view



- **Approx 10s of machines**
- **1-2 switches, 1000m cabling**

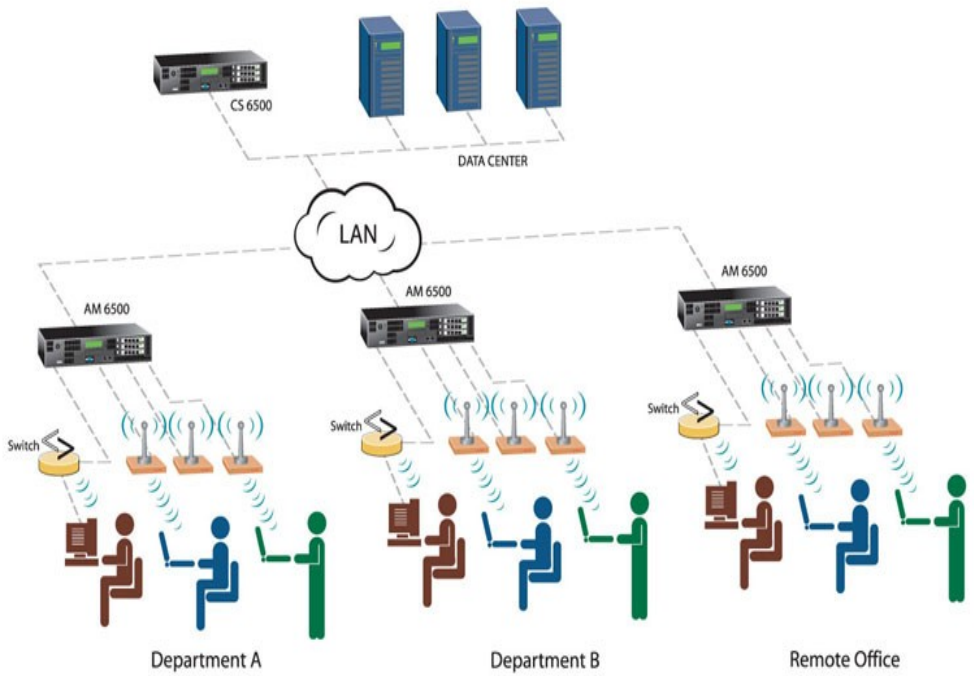
- A single subnet (dept) in an organization
  - Decentralized resource sharing (printers, files etc)
  - Ex:- A lab in KReSIT
- Hardware: Switches, cables
- Software: Security, Mgmt
- Typical IT spending
  - Around Rs. 500,000/- (excluding desktops)


M. Tech. Lab, Third Floor C wing
12 Core Fiber link
2Gbps OFC link
100Mbps CAT5 link
MTECH LAB1
MTECH LAB2
10.129.251.3
P330 Stack
From
Computer Centre
10.129.250.1
P580

Issues at the ‘micro’ level

- Application-related
  - Resource Sharing
    - “Somebody has changed the setting on this printer.”
  - Scalability and Performance
    - “This is too slow during the day. I’ll try it at night.”
- Network-related
  - Security
    - “Somebody seems to have broken into my machine.”
  - Administration
    - “Hey, there is an IP address conflict.”
- One solution strategy
  - Rudimentary IT administration: Move up one level

A ‘milli’ level view

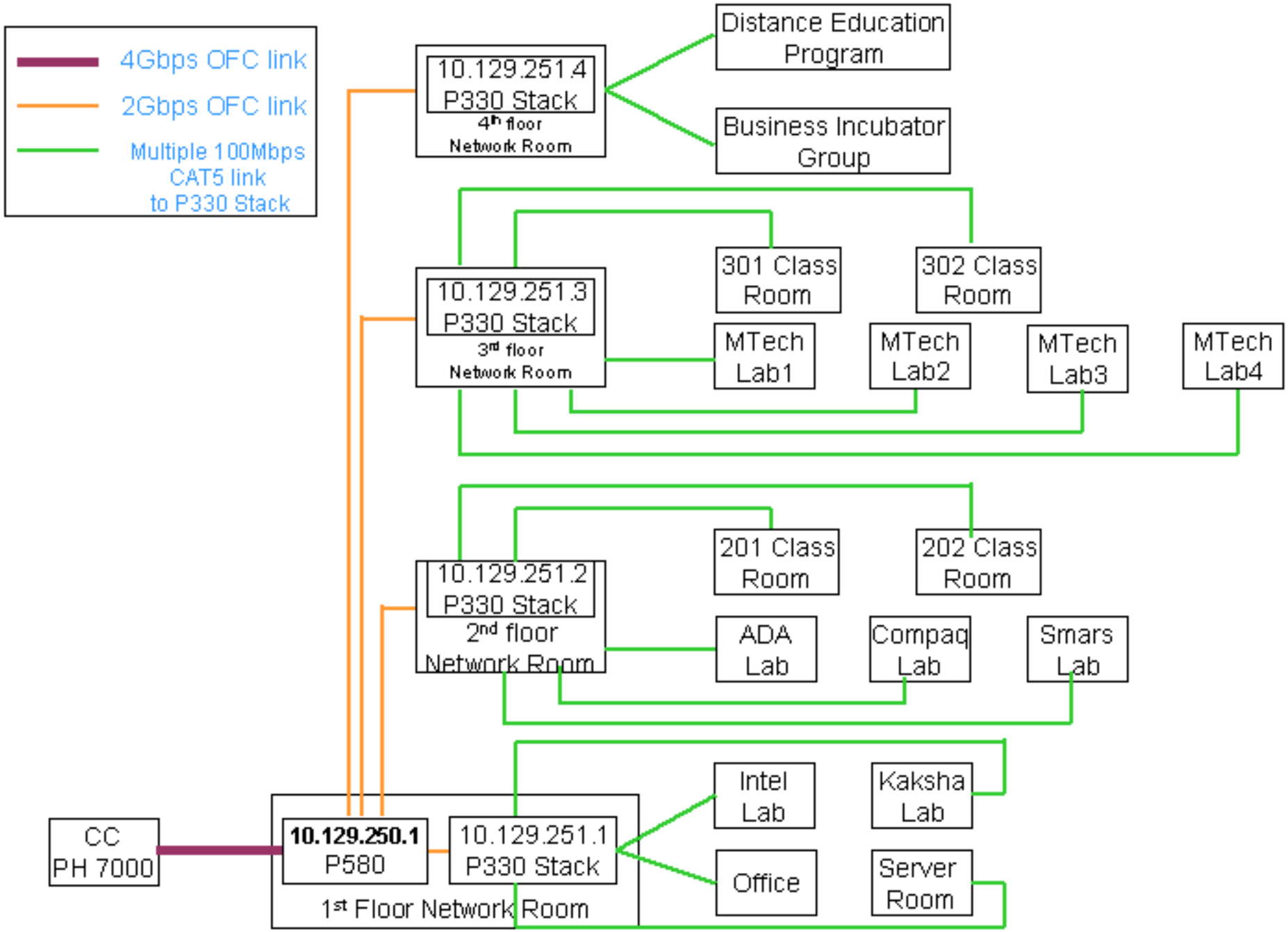


- A single ‘entity’ in an large organization
  - 100s of users
  - Ex:- KReSIT in IIT Bombay
  - Centralized model for data storage, security, running applications and network administration
- Hardware: Routers, Servers
- Software: Applications, Mgmt

- **Approx 100s of machines**
- **10-20 switches, 2-3 routers**
- **4-5 servers**

- Typical IT spending
  - Rs. 50,00,000/- for network
  - Rs. 3,00,00,000/- servers
  - Annual maintenance cost!

Network Diagram for C-Wing KReSIT

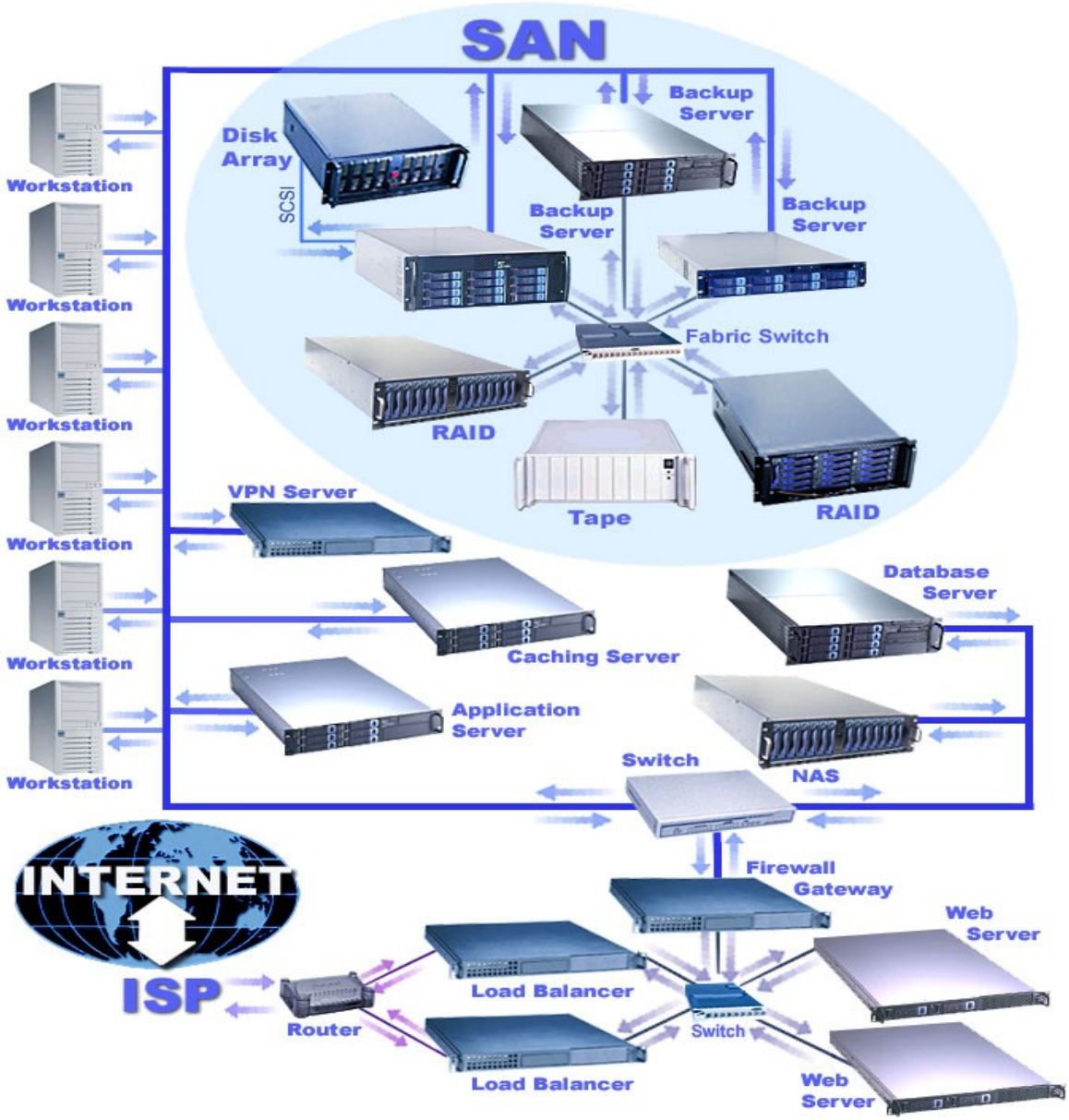


Issues at the ‘milli’ level

- Application-related
  - Sizing
    - “How many servers do I need and of what performance?”
  - Deployment
    - “How should I deploy my applications and other systems?”

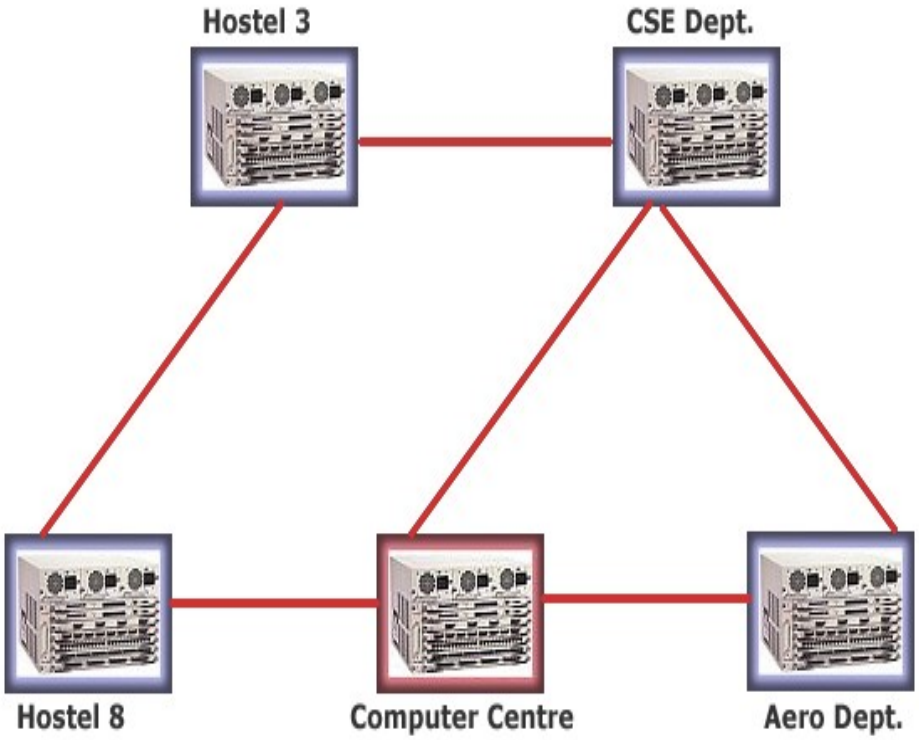
- Network-related
  - Sizing
    - “How much bandwidth do I need to keep users happy?”
  - Security
    - MAC flooding; ARP spoofing; Denial of Service
  - Administration
    - DHCP; Firewalls; Proxy servers; Logging

- The cost to manage storage is typically twice the cost of the actual storage system.



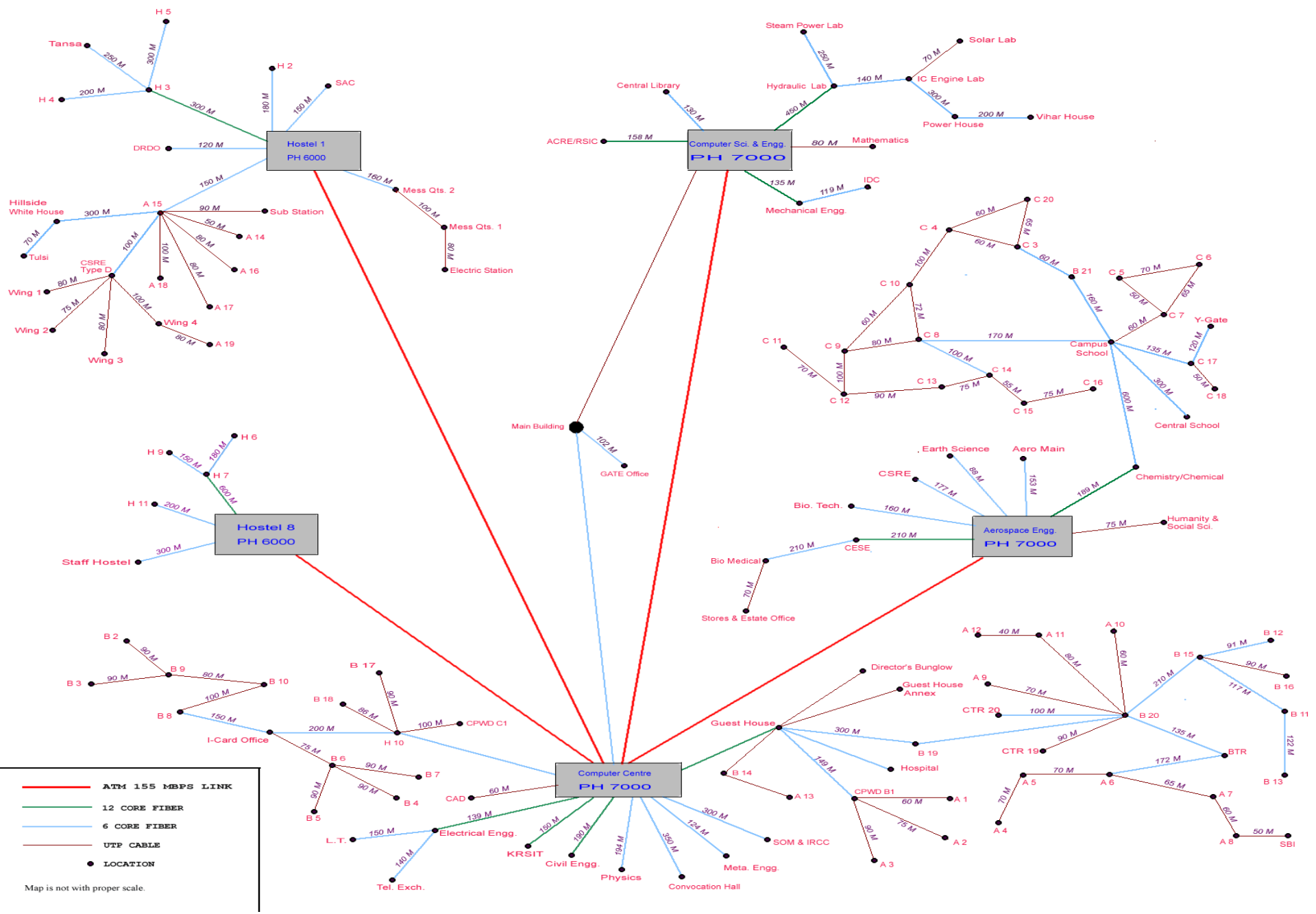
- IT manager, administrator, already has to deal with terrific complexity.
- The worst possible situation to be in is: trying to identify, root-cause, and resolve problems in such complex setups.

A ‘typical’ enterprise level view



- **Approx 10s of locations**
- **Approx 1000s of machines**
- **100s of switches, 10s of routers**

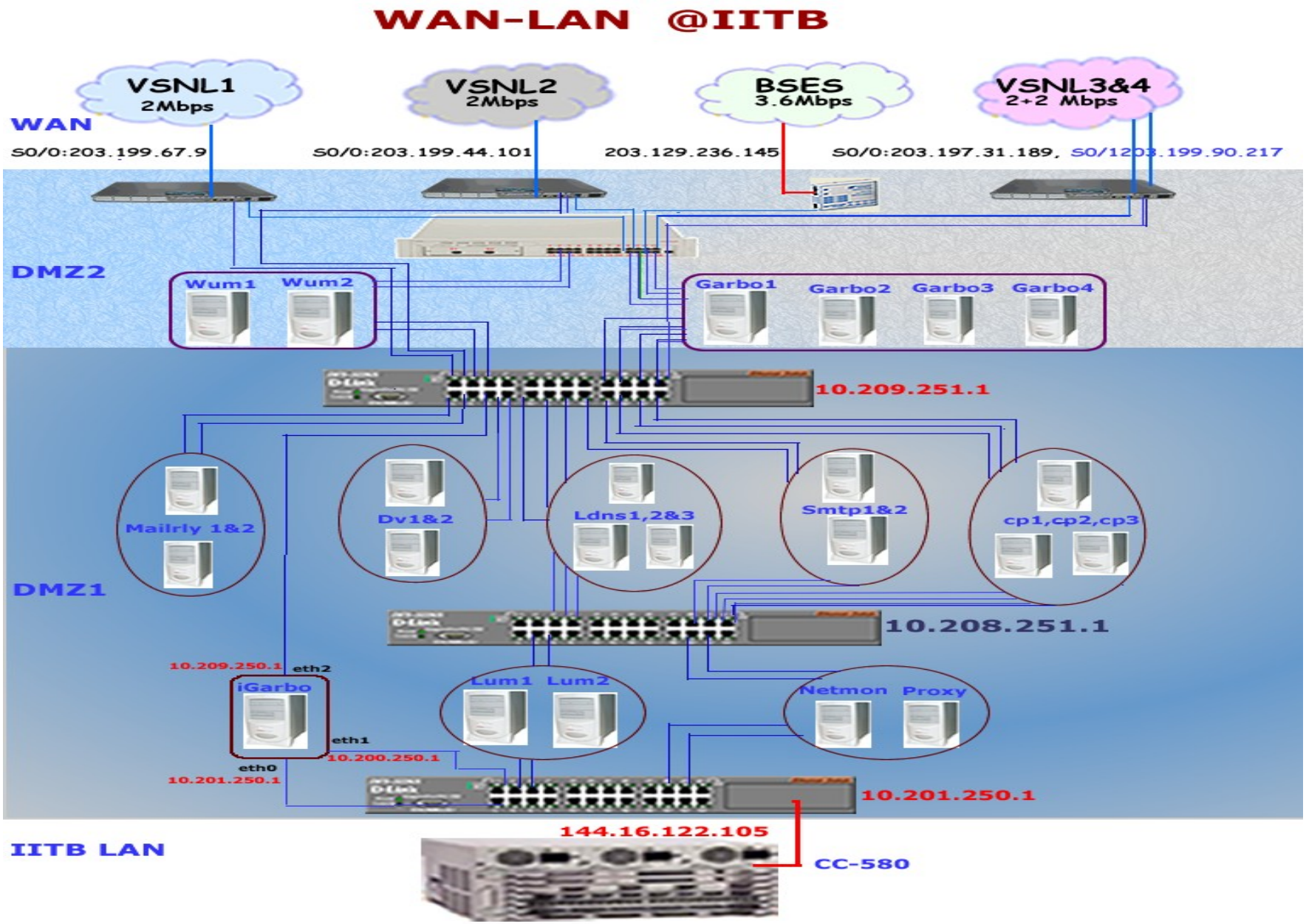
- A single organization
  - 1000s of users
  - Ex:- IIT Bombay
  - Multiple duplicate servers and more complex network
- Hardware: Routers, Servers
- Software: ERP, CRM, security, accounting and other systems
- Typical IT spending
  - Requirements are ever increasing
  - Bounded only by budget constraints!


Hostel 1
PH 6000
Hostel 8
PH 6000
Computer Sci. & Engg.
PH 7000
Aerospace Engg.
PH 7000
Computer Centre
PH 7000
Main Building
GATE Office
Hillside
White House
Tansa
Tulsi
CSRE
Type D
Wing 1
Wing 2
Wing 3
Wing 4
Staff Hostel
I-Card Office
DRDO
SAC
Sub Station
Mess Qts. 1
Mess Qts. 2
Electric Station
Steam Power Lab
Solar Lab
Hydraulic Lab
IC Engine Lab
Power House
Vihar House
Central Library
ACRE/RSIC
Mathematics
IDC
Mechanical Engg.
Campus School
Central School
Y-Gate
Chemistry/Chemical
Earth Science
Aero Main
CSRE
Bio. Tech.
CESE
Bio Medical
Stores & Estate Office
Humanity &
Social Sci.
Director's Bunglow
Guest House
Guest House
Annex
Hospital
CPWD B1
CPWD C1
CAD
Electrical Engg.
L.T.
KRSIT
Civil Engg.
Physics
Convocation Hall
Meta. Engg.
SOM & IRCC
Tel. Exch.
BTR
SBI
ATM 155 MBPS LINK
12 CORE FIBER
6 CORE FIBER
UTP CABLE
LOCATION
Map is not with proper scale.

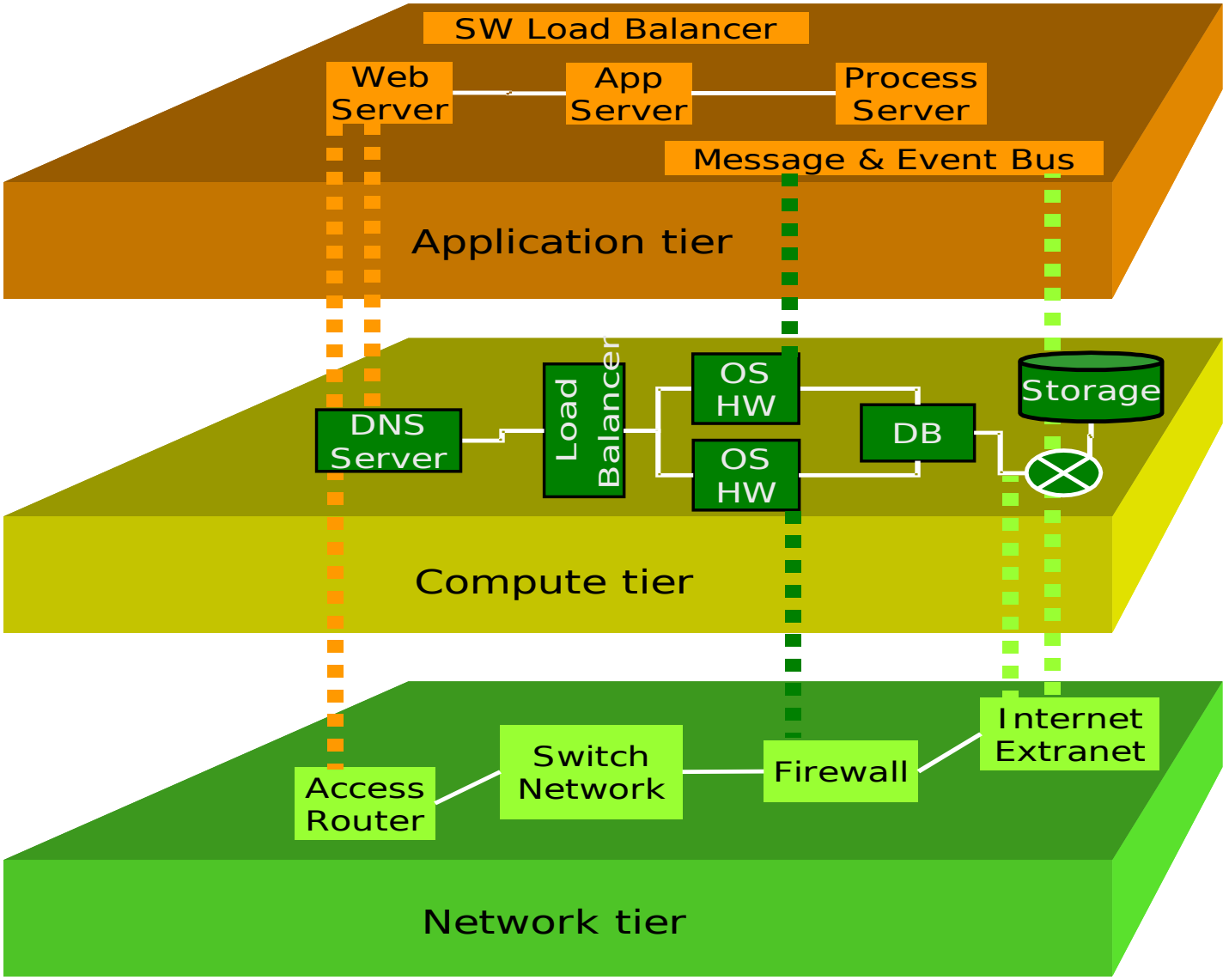
Issues at the 'typical' level

- Application-related
  - Interfaces
    - "How many interfaces should I provide for a service access?"
    - LAN, WAN, web, handheld devices…
  - Monitoring
    - "How should I ensure 'application' quality of service?"
    - Minimize down time, Auto alerts for overload…

- Network-related
  - Sizing: "How much Internet bandwidth do I need?"
  - Wireless: "How should I handle wireless devices?"
  - Security: "How should I setup firewalls, proxies and DMZ?"
  - Administration: "What are my authentication/access policies?"

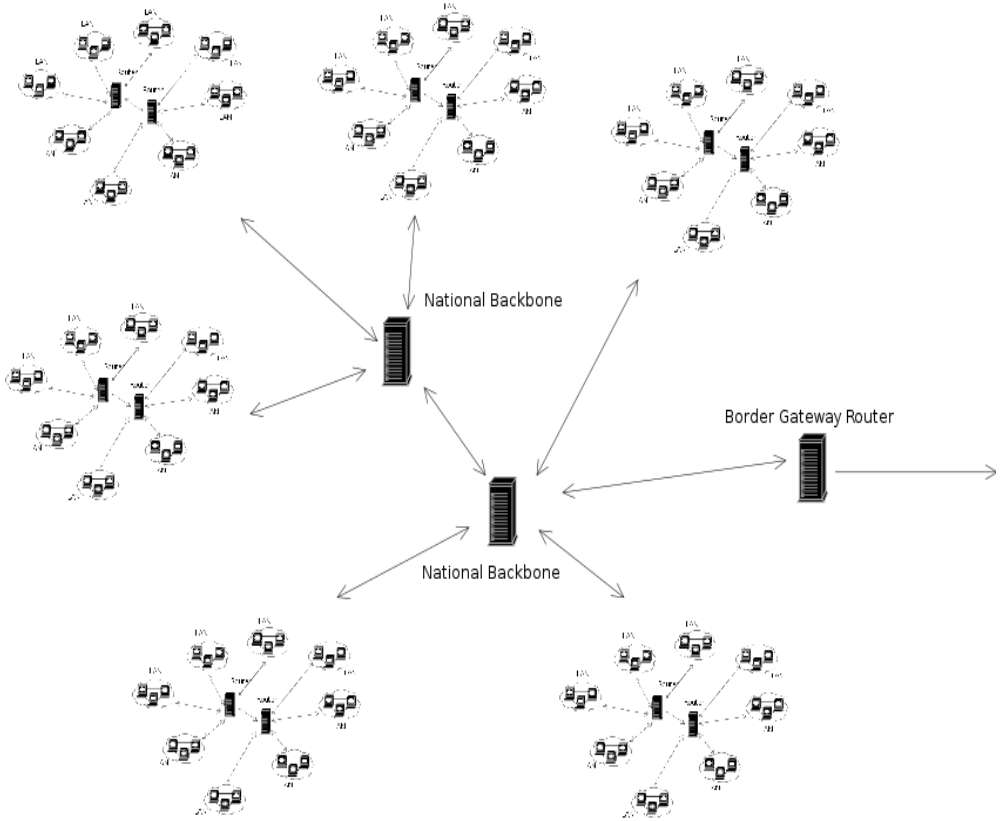

WAN-LAN @IITB
VSNL1
2Mbps
VSNL2
2Mbps
BSES
3.6Mbps
VSNL3&4
2+2 Mbps
WAN
S0/0:203.199.67.9
S0/0:203.199.44.101
203.129.236.145
S0/0:203.197.31.189,
S0/1203.199.90.217
DMZ2
Wum1
Wum2
Garbo1
Garbo2
Garbo3
Garbo4
10.209.251.1
Mailrly 1&2
Dv1&2
Ldns1,2&3
Smtp1&2
cp1,cp2,cp3
DMZ1
10.208.251.1
10.209.250.1
eth2
iGarbo
Lum1
Lum2
Netmon
Proxy
eth1
10.200.250.1
eth0
10.201.250.1
10.201.250.1
144.16.122.105
IITB LAN
CC-580

Tiered View of an Enterprise



Source: **Umesh Bellur, IIT Bombay**

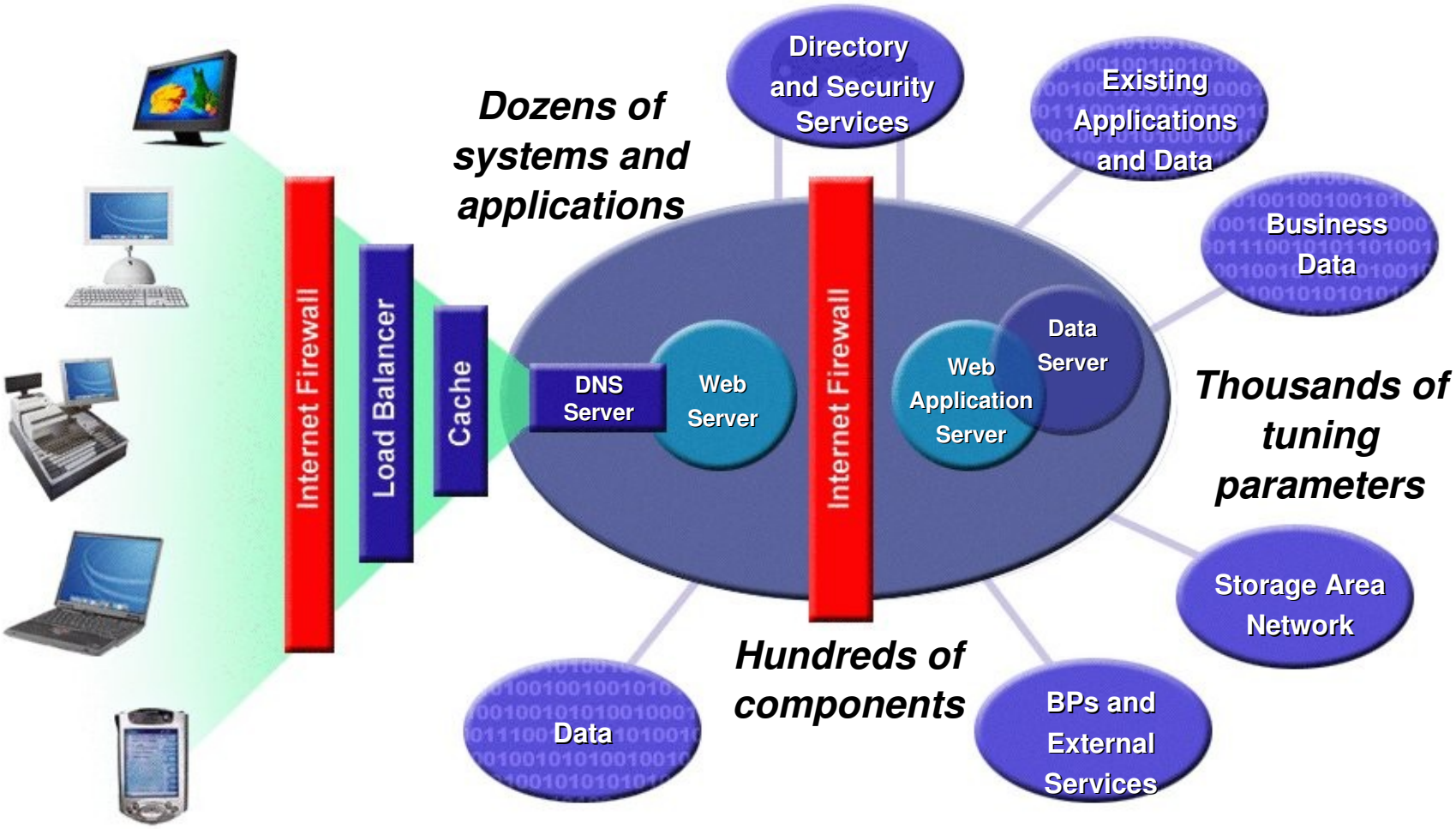
A ‘kilo’ level view



- **Approx 100s of locations**
- **Approx 10000s of machines**
- **1000s of switches, 100s of routers**

- A national network for a single organization
  - Ex:- LIC, NSDL
- Need to lease lines or use routing services provided by ISPs.
- Creation of a Wide Area Network Backbone
- Typical IT spending
  - Varies from tens to hundreds of crores

Complex heterogeneous infrastructures

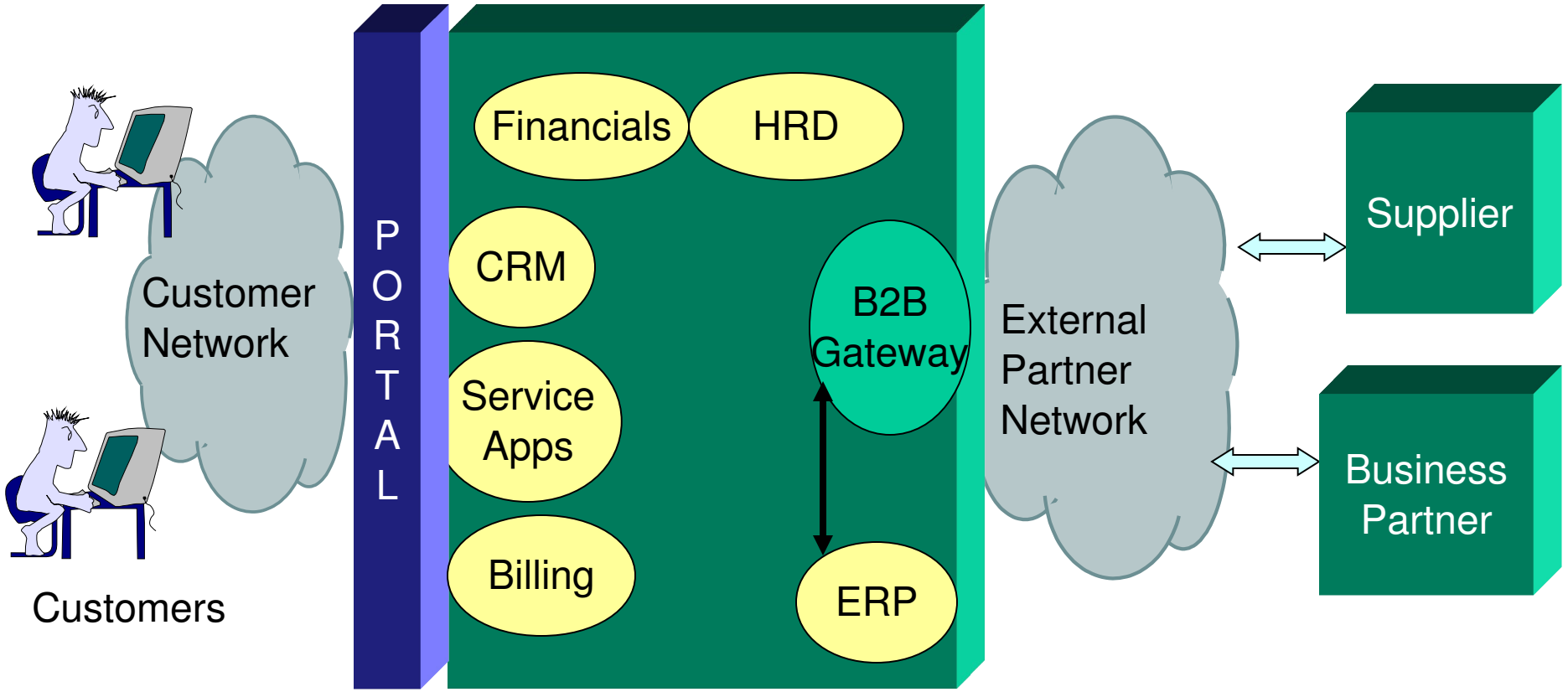


Issues at the ‘kilo’ level

- Application-related
  - Placement
    - “What are the optimal locations for my various applications?”
  - Tuning
    - “How should I tune my applications for optimal performance?”
  - Scalability
    - “How should I scale my applications for increasing usage?”

- Network-related
  - Sizing: “How should I provision my WAN/Internet connectivity?”
  - Security: “How do I cope with my security vulnerabilities?”
  - Backup: “What are my standby and fail-over mechanisms?”
  - Administration: “What are my policies for VPN and others?”

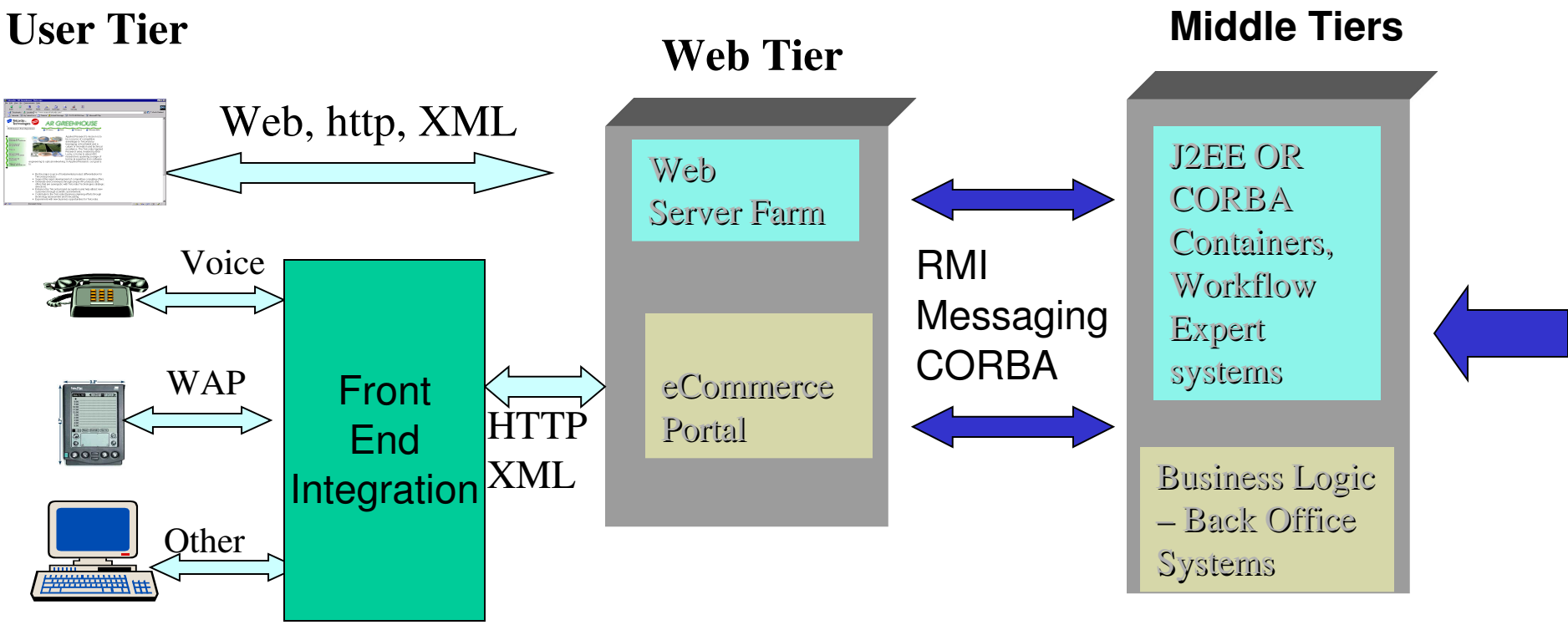
eBusiness Functional Architecture



Example: Amazon

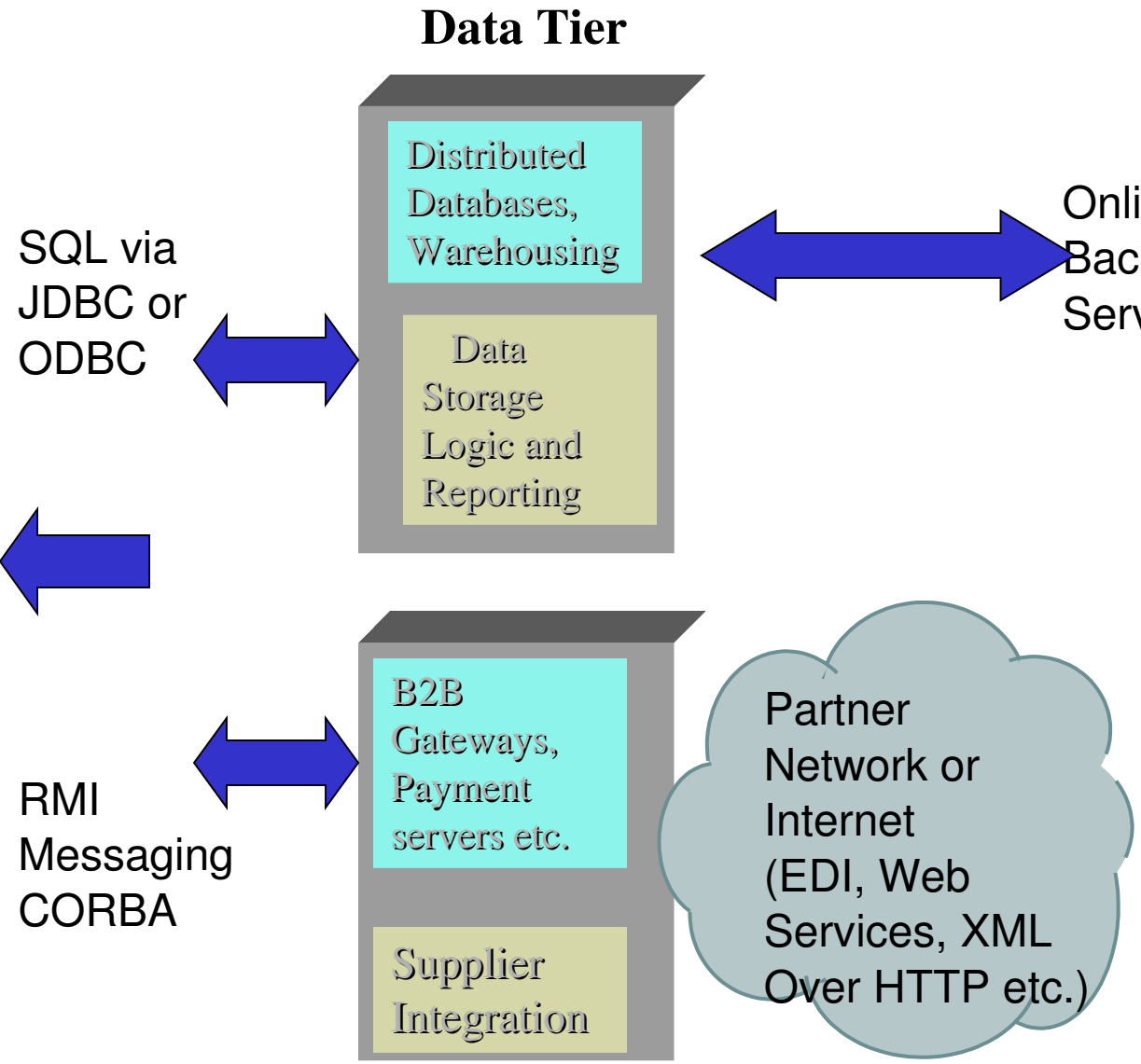
Source: **Umesh Bellur, IIT Bombay**

One Solution Architecture



Source: **Umesh Bellur, IIT Bombay**

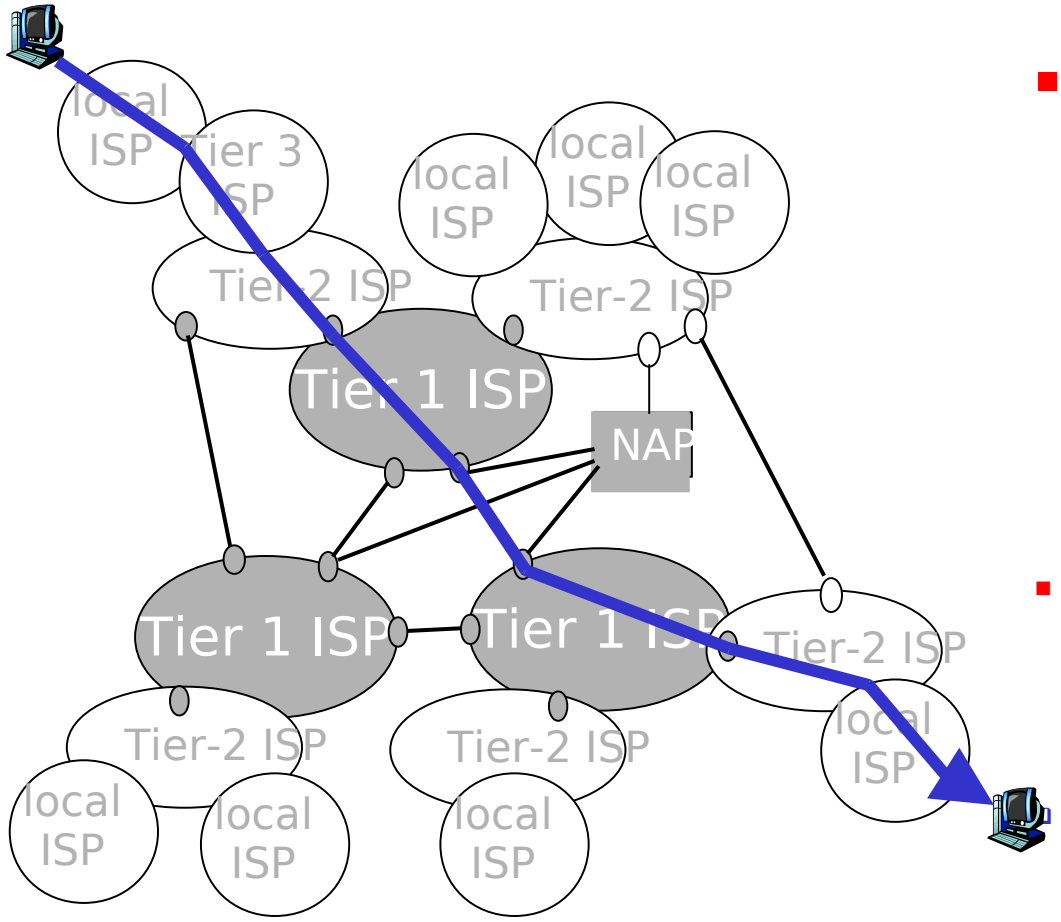
Solution Architecture (contd.)



- Application complexity overshadows the network
- Application may be unavailable despite network and bandwidth availability
- Need to architect systems for greater reliability, fault tolerance, scalability etc.

Source: **Umesh Bellur, IIT Bombay**

A ‘mega’ level view



- **Approx 10s of countries**
- **1000s of locations**

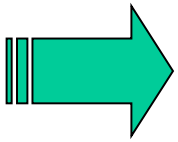
- An international network for a single organization
  - Ex:- Intel
  - Need to co-ordinate with international bandwidth providers
- A packet may have to pass through many networks!
  tier-2 ISP is *customer* of tier-1 provider
- Typical IT spending?

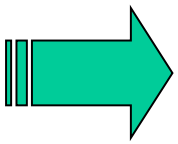
Issues at the ‘mega’ level

- Application-related
  - Aggregation
    - Centralized v/s distributed schemes for aggregation at the various data centers and applications.
  - Replication
    - Replication and caching mechanisms for faster access.
  - Robustness
    - Ensuring application availability despite various failures.

- Network-related
  - SLA: Service Level Agreements with bandwidth providers.
  - Administration: Early fault diagnosis and warning systems.
  - Security: This problem only gets worse!

Security: Speed of network attacks





1980s-1990s

Usually had weeks or months to put some defense in place.

2000-2003

Attacks progressed over hours, time to assess danger and impact.

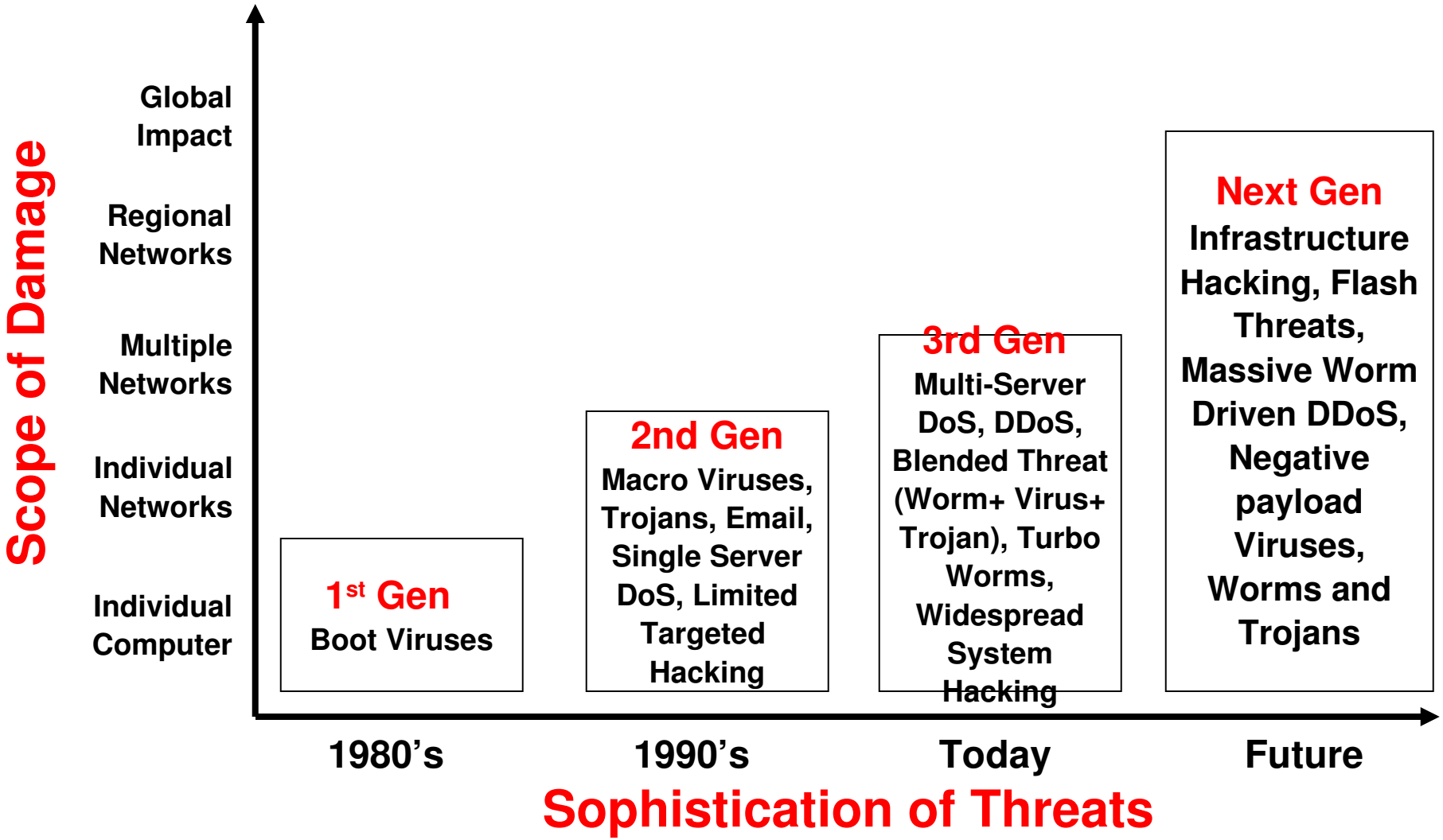
Time to implement defense.

2003-Future

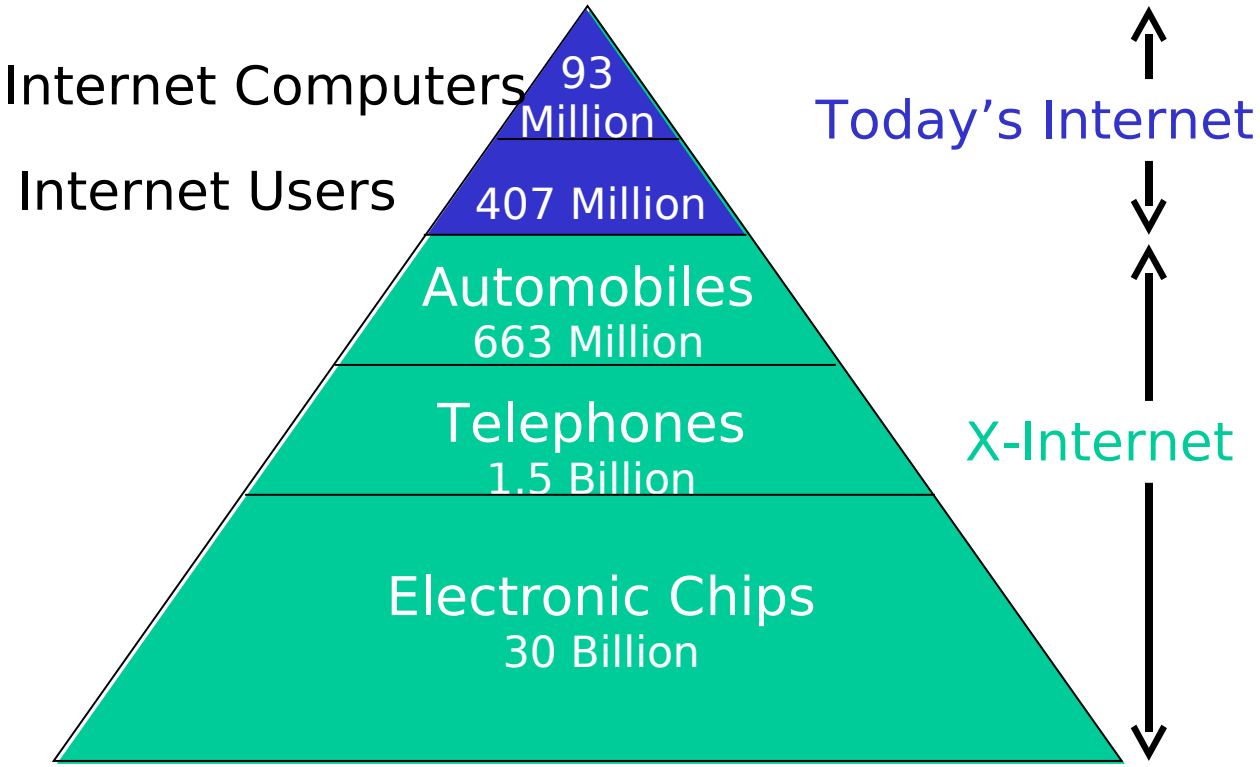
Attacks progress on the timeline of seconds.

SQL Slammer Worm:
Doubled every 8.5 seconds
After 3 min : 55M scans/sec
1Gb Link is saturated after one minute

Security: Threat Evolution



A ‘giga’ level view

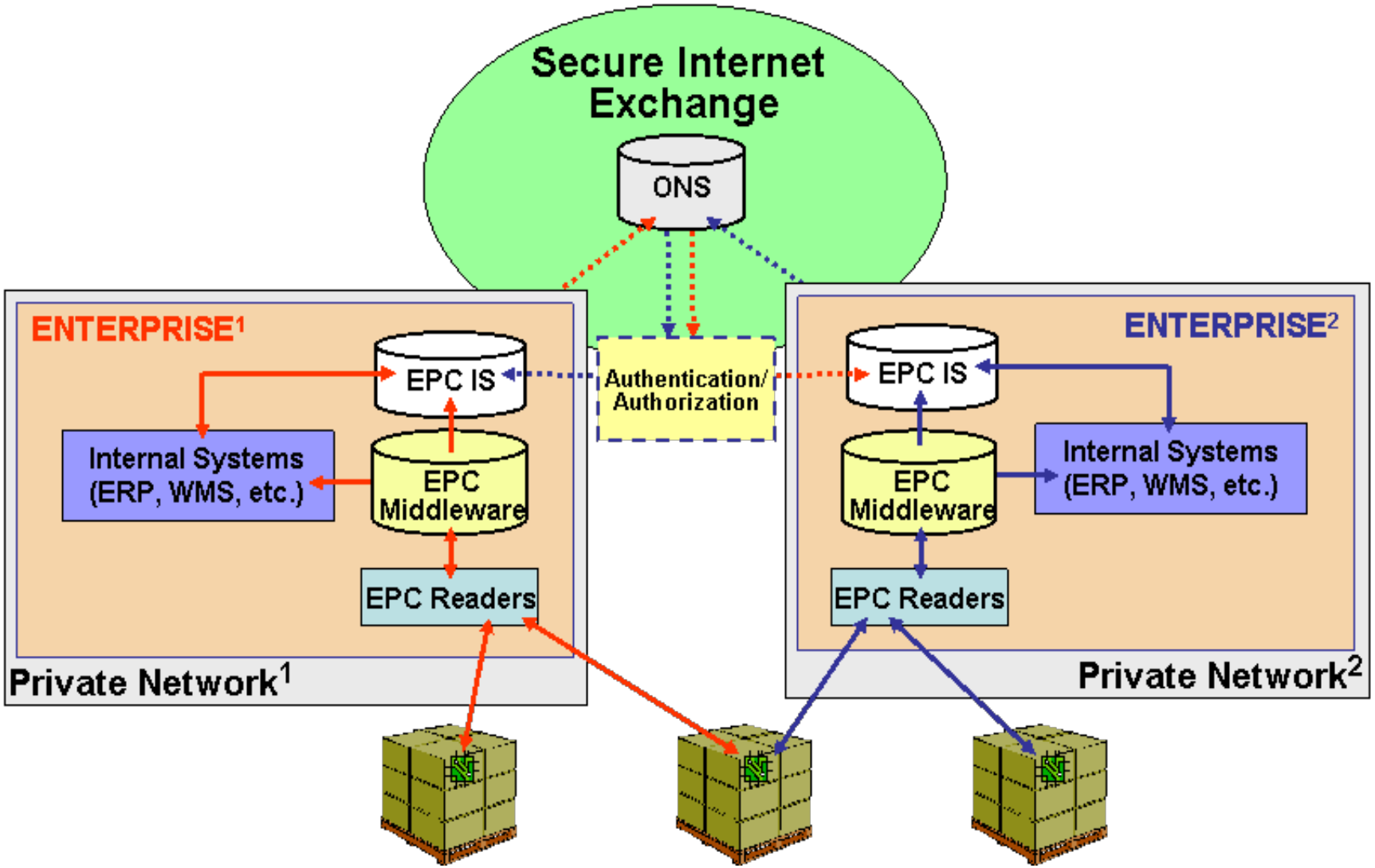


- Impact of new technologies
  - Wireless access
  - Embedded ctrl
  - RFID tagging
- Not hard to imagine an international network, spanning across multiple, diverse organizations
  - Internet of Things

- **100s of organizations**
- **100s of countries**
- **Millions and billions of devices**

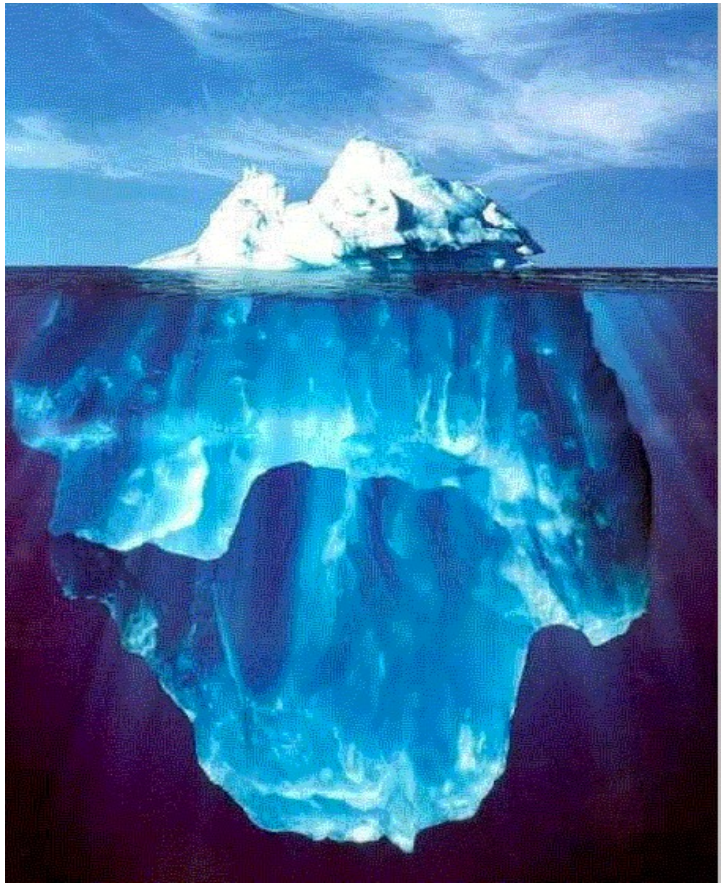
Forrester Research, 2001

The EPC model: Internet of Things



Source: **www.epcglobalinc.org**

Enterprise networks: The complete picture



Networking and Applications
Connectivity and Services

Maintenance
Scalability and robustness
Fault tolerance
Load balancing
Integration across systems
Security

References

- A.S. Tanenbaum. Computer Networks. Pearson Education, 2003.
- L.L. Peterson and B.S. Davie. Computer Networks: A Systems Approach. Morgan Kaufmann, 2002.

- J. Schiller, Mobile Communications, Addison Wesley, 2003.
- Y-B. Lin and I Chlamtac, Wireless and Mobile Network Architectures, Wiley, 2001.

Thank You

Other Tutorials at: www.it.iitb.ac.in/~sri

Google Search: Sridhar Iyer IIT Bombay

Contact Details:

Sridhar Iyer

School of Information Technology

IIT Bombay, Powai, Mumbai 400 076

Email: sri@it.iitb.ac.in