Routers and Switches by Steve Mackay from Engineering Institute of Technology

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Topics

Attend this complimentary session and gain an understanding on how routers and switches operate based on the TCP/IP suite of protocols.

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Topics

- Detail how TCP/IP protocol works
- How a router and switch operate
- Examine Routing Basics
- Simple Troubleshooting Tips

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Why Bother ?

Useful to understand how routers work so that you can more effectively design and troubleshoot your TCP/IP networks.

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1.0 How TCP/IP Works

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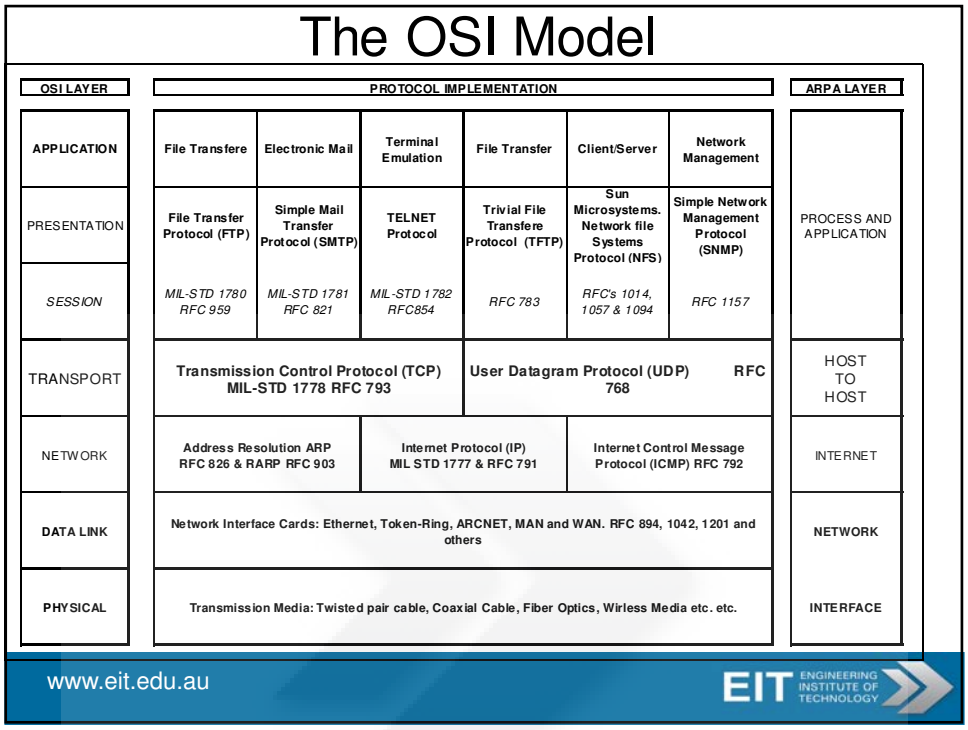
The OSI Model



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IP Protocol

- Primarily for routing
- Version 4 uses 32-bit address
- Version 6 uses 128-bit address
- IP is hierarchical vs MAC which is flat and unique for each node

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IP address Notation

- The IP address consists of 32 bits, e.g. 11000000011001000110010000000001.
- Four octets, which for ease of reference could be called a,b,c,d or w,x,y,z. We then convert each octet to decimal and write it thus:

- w x y z
- **11000000.01100100.01100100.00000001**
- **or**
- **192.100.100.1**

NetId and HostId

- Two portions to IP address
- Network ID (NetID)
- Host ID (HostID)

Transmission Control Protocol

- Connection oriented
- Reliable
- Establishes a session before data is transmitted
- Significant overhead in processing and header

TCP functions

- Fragmentation
- Data stream reconstruction
- Receipt acknowledgement
- Socket services for multiple connections
- Packet verification and error control
- Flow Control
- Packet sequencing and reordering

Ports and Sockets

- TCP needs to know which process on a particular machine the packet is destined for.
- Done by port assignments
- Specific port numbers are assigned by the IANA
- Well know ports
- IP address + Port number = socket
- Thus three addresses are used: (MAC/IP/Port#)

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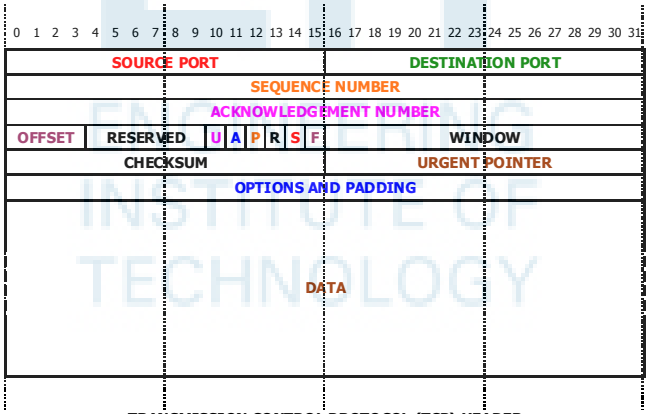

TRANSMISSION CONTROL PROTOCOL (TCP) HEADER

U	URG	Urgent Pointer Field iis Valid
A	ACK	Acknowledgement is Valid
P	PSH	This Segment Requests a Push
R	RST	reset the Connection
S	SYN	Synchronise Sequence Numbers
F	FIN	Sender at the End of its Byte Stream

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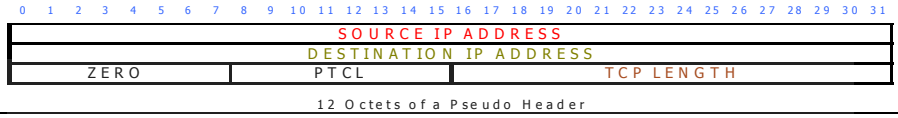
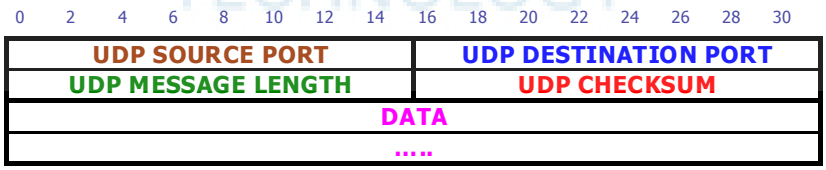
TCP Header Format



User Datagram Protocol

The format of Fields in a UDP Datagram



APPLICATION LAYER PROTOCOLS

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2.0 How a Router and Switch Operate

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Fundamentals

- Routers are used to interconnect multiple networks.
- Connected over wide geographical areas with WAN's

Routing

- Act of moving information across an Internet work from a source to a destination

Routing metrics

- Path length
- Reliability
- Delay
- Bandwidth
- Load
- Communication cost

Components of Router

- CPU and RAM
- BIOS
- Operating System (eg Cisco's Internetwork Operating system)
- Motherboard
- I/O Ports

Two methods of Operation

- Static routing
- Dynamic Routing
  - Distance Vector
  - Link-state
  - Hybrids

Static Routing

- Fixed static routes configured by network administrator.
- Optimum routes are programmed in.
- Good for security as ingress into yur network can be controlled.

Three methods of dynamic routing

- Distance vector
- Link-state
- Hybrids

Distance-vector routing

- Periodically pass copies of their tables to immediate network neighbours.
- Each recipient adds a distance vector to its table.

Advantages of distance-vector

- Simple to configure/maintain and use.
- RIP uses only distance to work out best route.

Drawbacks to Distance-vector

- Some time to converge on new understanding of network.
- Bandwidth and traffic levels can affect performance of network.

Link-state routing

- Shortest path first protocols
- Exchange of link-state advertisements (LSA) to other routers.
- LSA's are triggered by an event rather than running periodically.

Disadvantages of Link State

- Flood the network during initial discovery process
- Memory and processor intensive

Advantages

- Gracefully weather effects of topology changes
- Lower overheads as no time-driven updates
- Better scalability for networks

Hybridized Routing

- Use distance vector metrics
- More accurate than conventional distance-vector protocols
- Converge more rapidly than distance-vector but avoid overheads of link-state updates.
- Best example is EIGRP.

Convergence

- Whenever a change occurs in a network's topology, all routers must develop a new understanding of new topology.
- Routers take time to converge to the new consensus of what the topology is.

3.0 Routing Protocols

Routing Protocols

- RIP and
- RIP 2
- IGRP
- OSPF

Routing Information Protocol

- One of the oldest routing protocols.
- RIP uses a special packet to collect and share information about distances.
- RIP is a *routing* protocol; not a *routed* protocol (e.g. TCP/IP).

Operation of RIP

- Routers periodically pass copies of their routing tables to immediate neighbours.
- Each recipient adds a distance vector to the table and forwards the table to its immediate neighbours.
- RIP uses as a metric the hop count.
- RIP only records one route per destination (even if there are more).

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Limitations of RIP (Routing Information Protocol)

- Hop count restriction
- Least hop path
- High routing overhead
- Routing flexibility is not allowed

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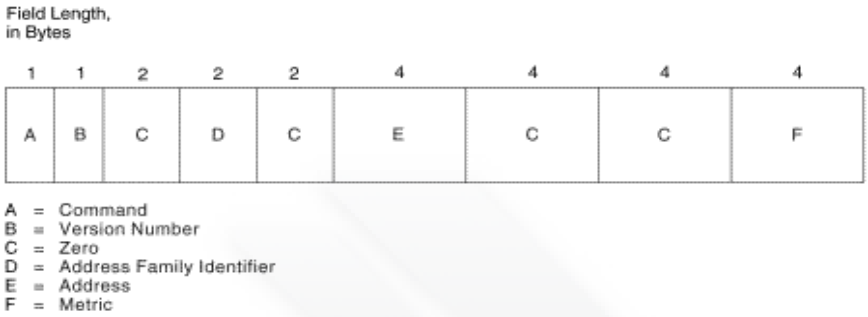
RIP Packet format



RIP packet fields

- Command
- Version number
- Zero
- Address-Family Identifier (AFI)
- Address
- Metric

Routing table

Destination	Next hop	Distance	Timers	Flags
Network A	Router 1	3	t1, t2, t3	x, y
Network B	Router 2	5	t1, t2, t3	x, y
Network C	Router 1	2	t1, t2, t3	x, y
.	.	.	.	.
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Routing table

Routing table provides:

- Ultimate destination
- Next hop on the way to that destination
- A metric

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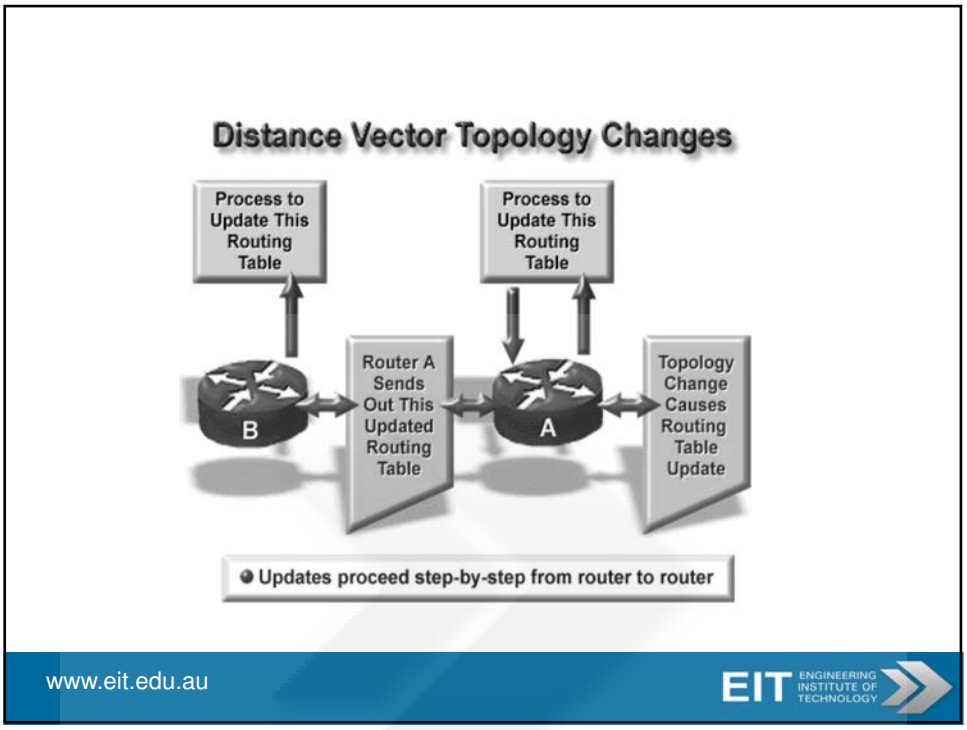
Routing database

- IP Address
- Gateway
- Distance
- Route change flag
- Timers

RIP algorithm

- Update
- Propagation



RIP-2

- Authentication
- Subnet Masks
- Next Hop IP Addresses
- Multicasting RIP-2 messages

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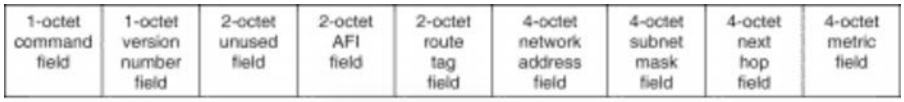
IP RIP 2 packet



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IP RIP 2 packet format fields

- Command
- Version
- Address-Family Identifier (AFI)
- Route tag
- IP address
- Subnet mask
- Next hop
- Metric

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Limitations of RIP-2

- 15-hop maximum
- Counting to infinity (e.g. routing loop)
- Static distance vector metrics
- Lack of alternative routes (single routes)

Interior Gateway Routing Protocol (IGRP)

Goals of IGRP

- Stable routing
- Fast response to changes
- Low overhead
- Splitting traffic
- Account error rates
- Handle multiple types of service

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Metrics

- Hop count
- Packet size (Maximum Transmission Unit - MTU)
- Link's bandwidth
- Delay
- Loading
- Reliability

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Formula - Metric

- Metric = K * Bandwidth + (K2 * Bandwidth)/(256 - Load) + K3 * Delay
- K1,K2 and K3 are weighting factors

Reliability added in...

- Metric = Metric * [K5/(reliability +K4)

Limitations of IGRP

- Does not include subnet mask information
- Does not support the use of VLSM
- Sends updates to the broadcast address

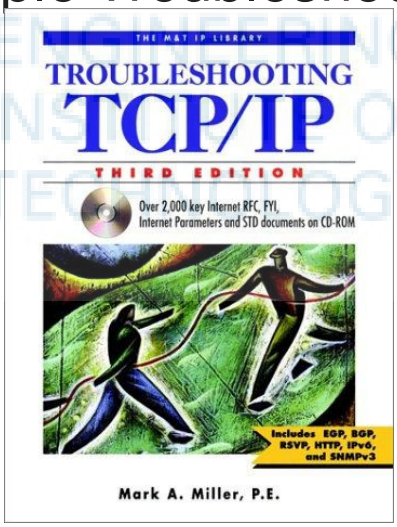
Open Shortest Path First (OSPF)

- Link State Routing Protocol
- Distance vector know nothing about topology of network
- OSPF assign a “path cost” to routes
- Divide reference bandwidth by circuits preconfigured bandwidth

Example of calculation

- Cisco uses reference bandwith of 100MBps
- 100 MBps circuit has an OSPF cost of 100/100 = 1
- A 1.544Mbps circuit has an OSPF cost of 100/1.544 = 65
- OSPF routers pick the lowest cost path (i.e. highest speed)

4. Simple Troubleshooting Tips



Network Troubleshooting

- Knowledge of networking protocols
- Understanding of networks' topology and layout
- Troubleshooting tools
- Some luck ? Preferably not.

Network Troubleshooting (cont.)

- Utilisation on the Ethernet network
- Low utilisation but high errors
- High number of packets but low data transfer

TCP/IP Utility Programs for Troubleshooting

- netstat
- ping
- traceroute
- arp
- ripquery

Example of the use of a few of the TCP/IP utilities together

- ping
- netstat-nr
- Tracert (or traceroute)

Unreliable Connections

- ping
- tracert (or traceroute)
- netstat
- ping-f
- netstat

Network Congestion

- ping
- tracert(or traceroute)

Thank You For Your Interest

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