ISP Network Design

ISP Workshops

Last updated 27th February 2015

ISP Network Design

- PoP Topologies and Design
- Backbone Design
- Upstream Connectivity & Peering
- Addressing
- Routing Protocols
- Security
- Out of Band Management
- Operational Considerations

Point of Presence Topologies

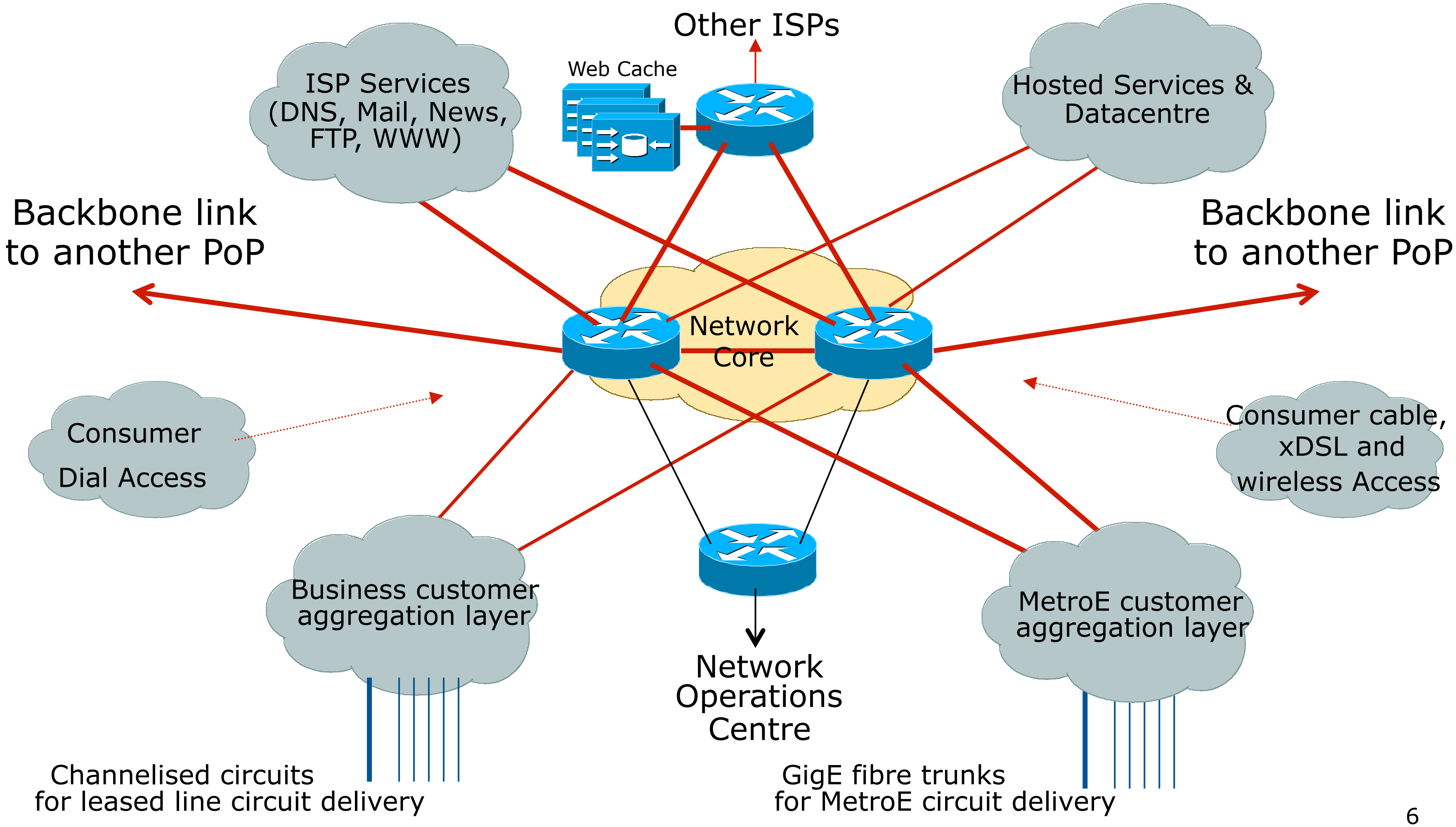
PoP Topologies

- Core routers – high speed trunk connections
- Distribution routers and Access routers – high port density
- Border routers – connections to other providers
- Service routers – hosting and servers
- Some functions might be handled by a single router

PoP Design

- Modular Design
- Aggregation Services separated according to
  - connection speed
  - customer service
  - contention ratio
  - security considerations

Modular PoP Design



Modular Routing Protocol Design

- Modular IGP implementation
  - IGP “area” per PoP
  - Core routers in backbone area (Area 0/L2)
  - Aggregation/summarisation where possible into the core
- Modular iBGP implementation
  - BGP route reflector cluster
  - Core routers are the route-reflectors
  - Remaining routers are clients & peer with route-reflectors only

Point of Presence Design

PoP Modules

- Low Speed customer connections
  - ADSL2, Cable, Public Wireless, PSTN access
  - Low bandwidth needs
  - Low revenue, large numbers
- Business customer connections
  - 10Mbps to 100Mbps speed range
  - Delivery over SDH or MetroEthernet links
  - Medium bandwidth needs
  - Medium revenue, medium numbers

PoP Modules

- Highband Business customer connections
  - From 100Mbps to over 1Gbps
  - Ethernet, Fibre, or high end SDH
  - High bandwidth needs
  - High revenue, low numbers

PoP Modules

- PoP Core
  - Two dedicated routers
  - High Speed interconnect
  - Backbone Links ONLY
  - *Do not touch them!*
- Border Network
  - Dedicated border router to other ISPs
  - The ISP's "front" door
  - Transparent web caching?
  - Two in backbone is minimum guarantee for redundancy

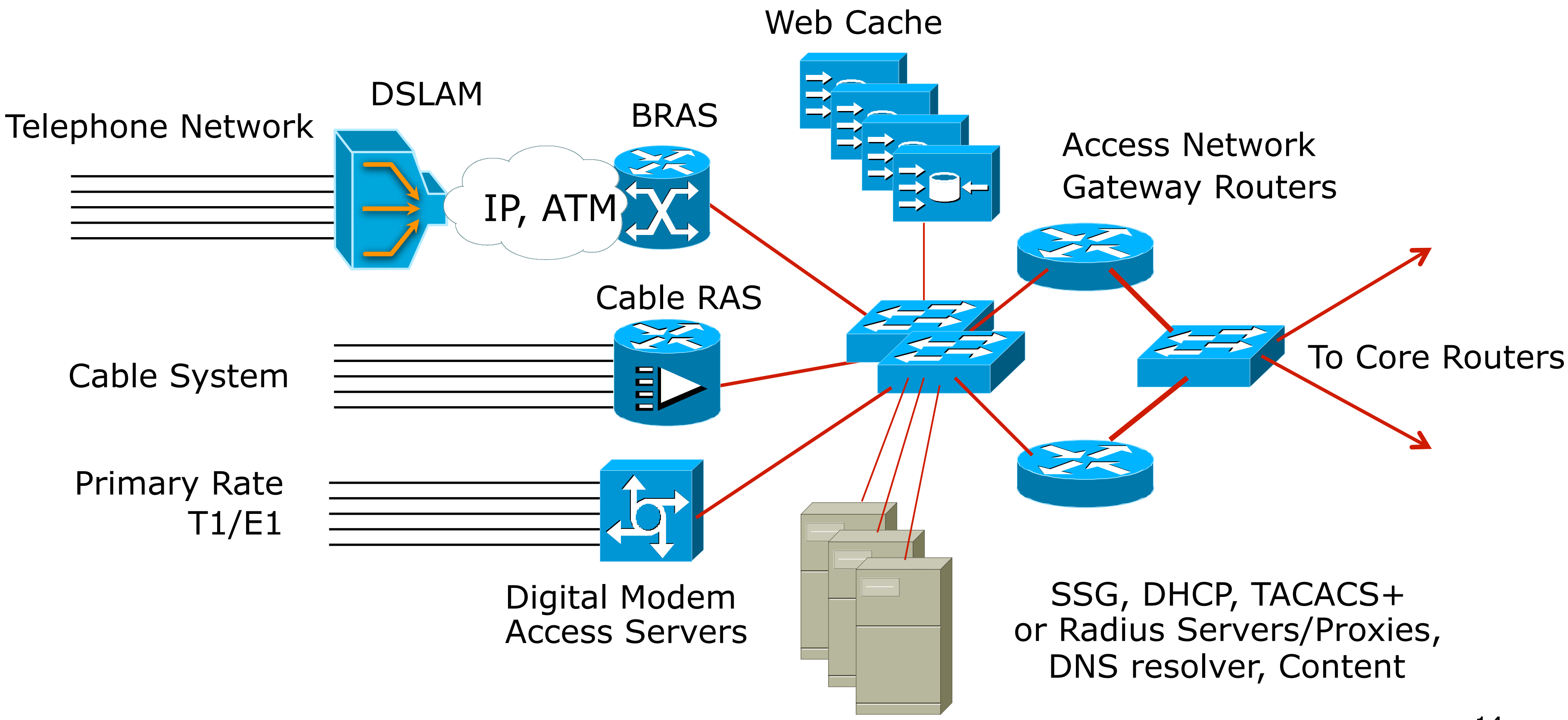
PoP Modules

- ISP Services
  - DNS (cache, secondary)
  - News (still relevant?)
  - Mail (POP3, Relay, Anti-virus/anti-spam)
  - WWW (server, proxy, cache)
- Hosted Services/DataCentres
  - Virtual Web, WWW (server, proxy, cache)
  - Information/Content Services
  - Electronic Commerce

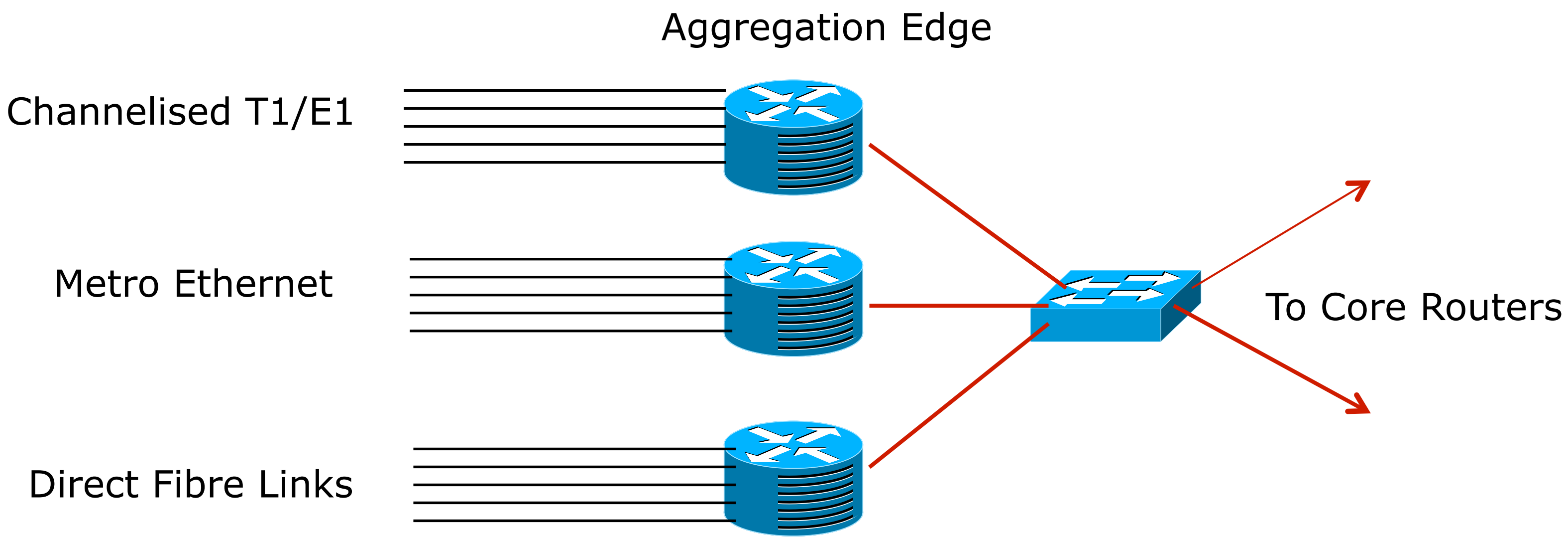
PoP Modules

- Network Operations Centre
  - Consider primary and backup locations
  - Network monitoring
  - Statistics and log gathering
  - Direct but secure access
- Out of Band Management Network
  - The ISP Network “Safety Belt”

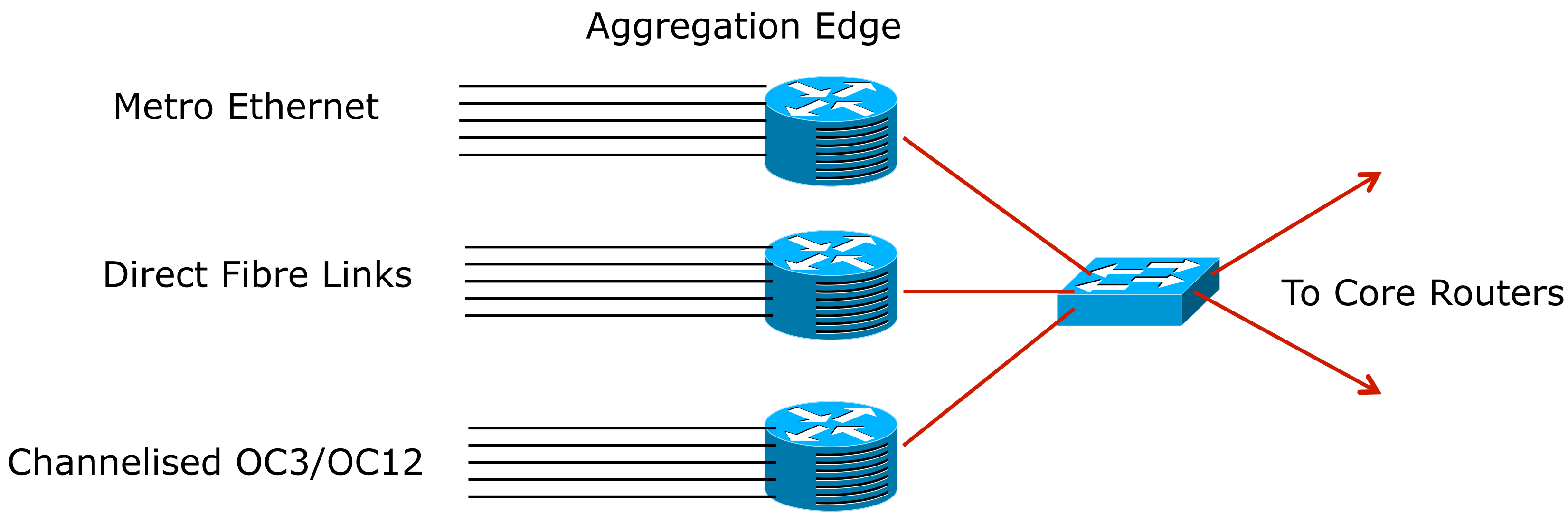
PSTN & Broadband Access Module



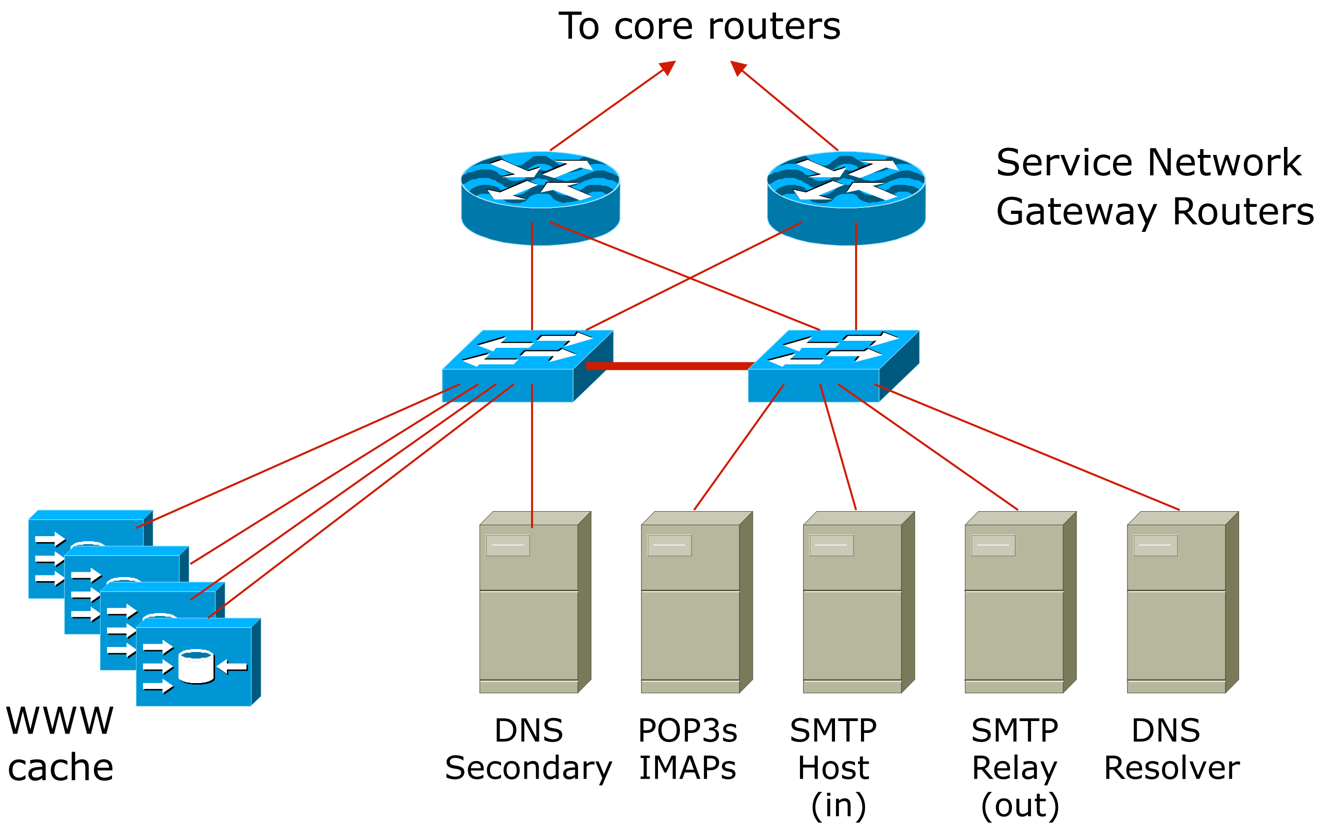
Business Customer Access Module



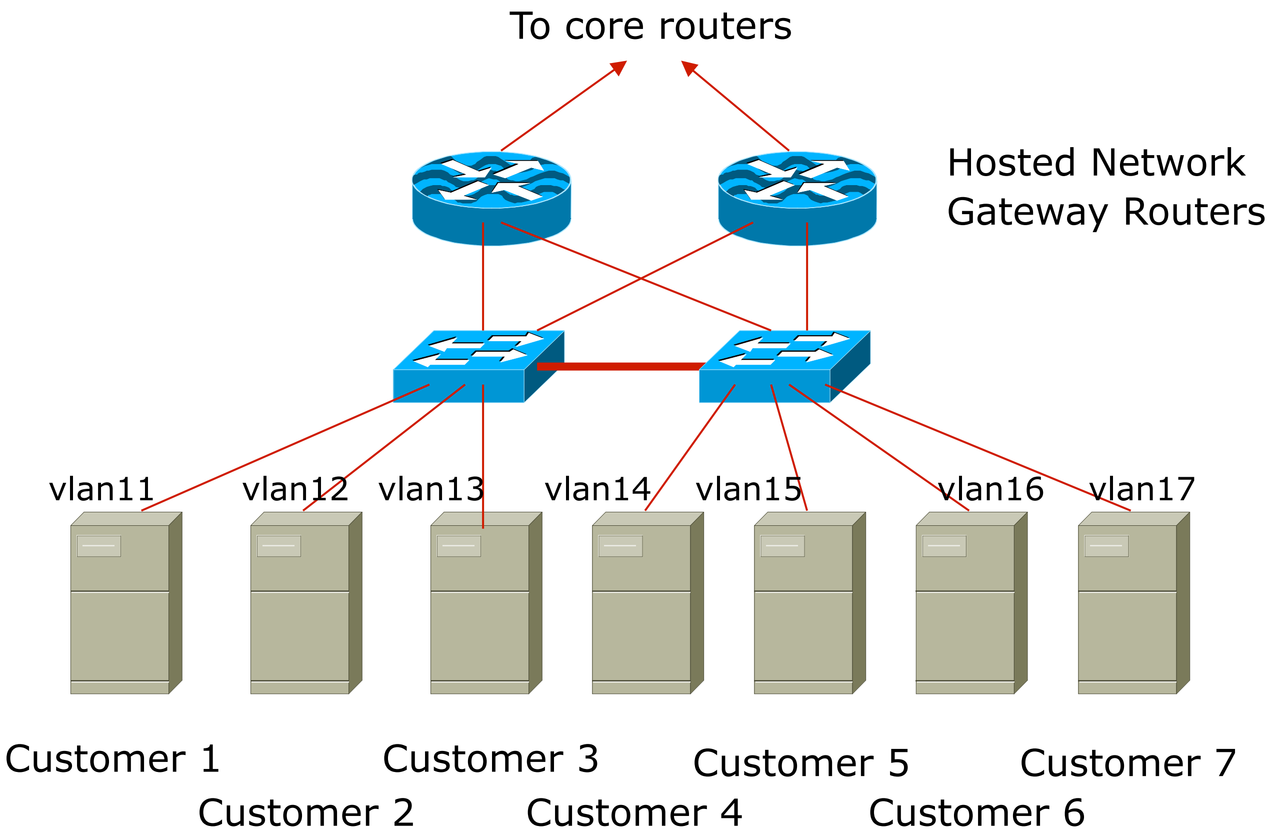
High Speed Access Module



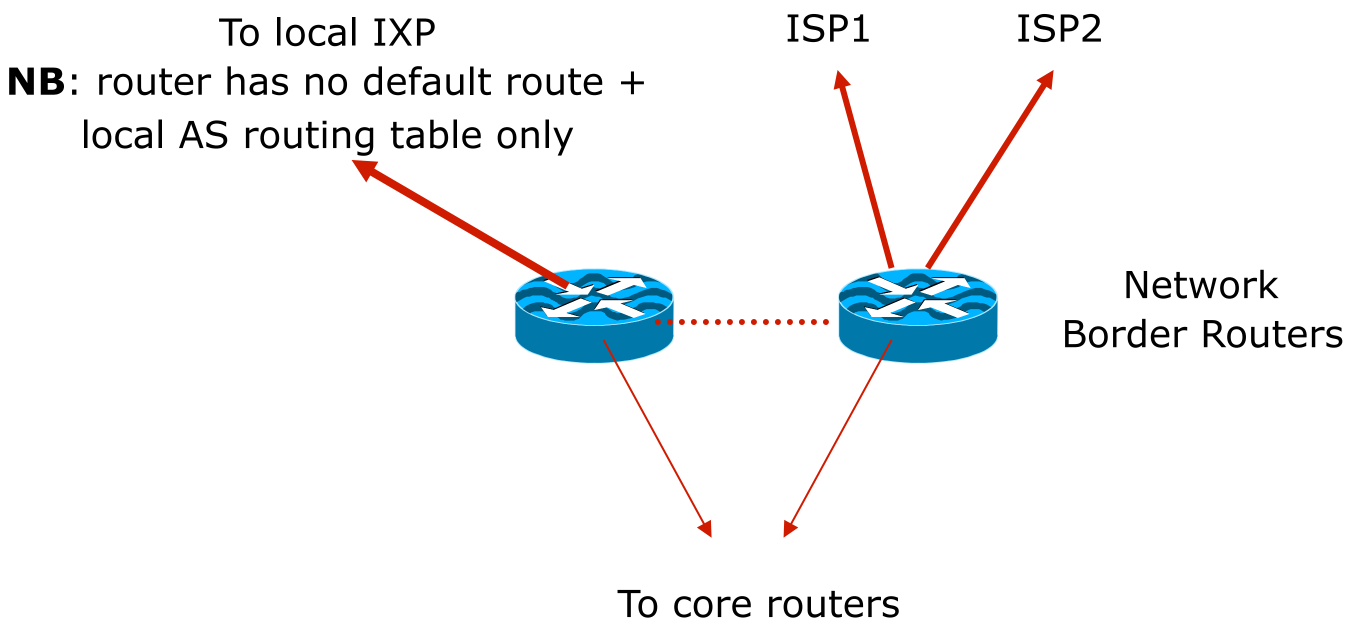
ISP Services Module



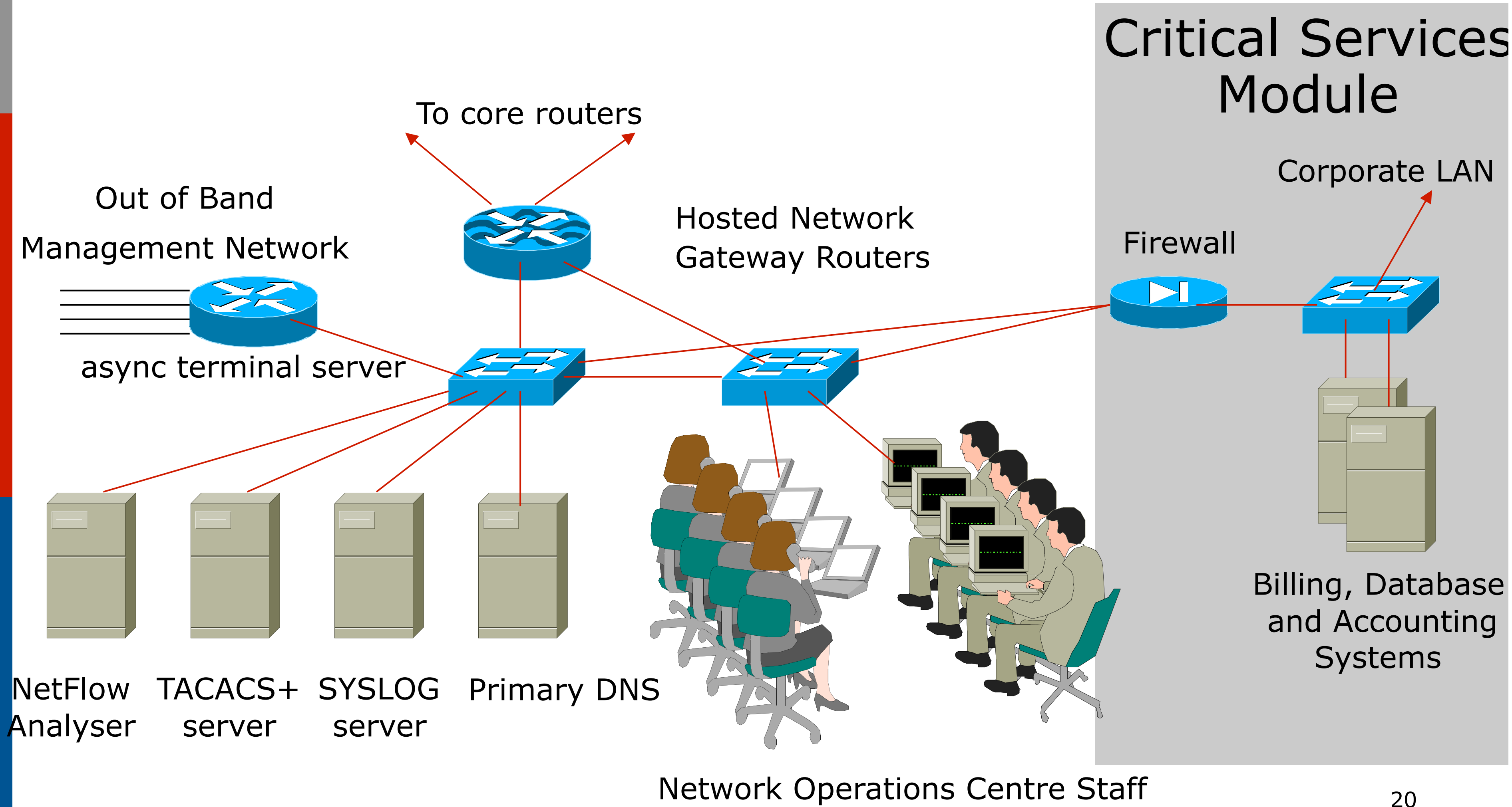
Hosted Services Module



Border Module

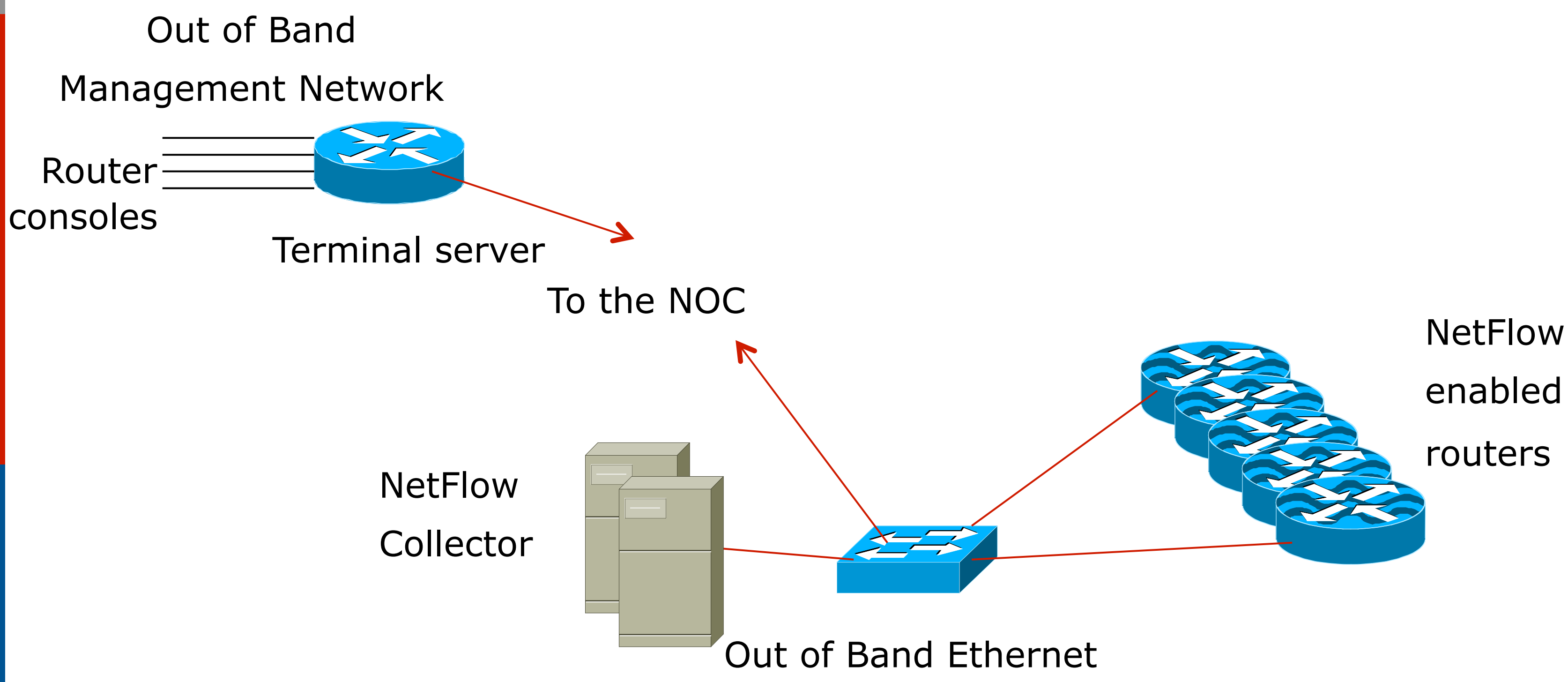


NOC Module



Critical Services Module
To core routers
Corporate LAN
Out of Band
Management Network
Hosted Network
Gateway Routers
Firewall
async terminal server
Billing, Database and Accounting Systems
NetFlow Analyser
TACACS+ server
SYSLOG server
Primary DNS
Network Operations Centre Staff

Out of Band Network



Backbone Network Design

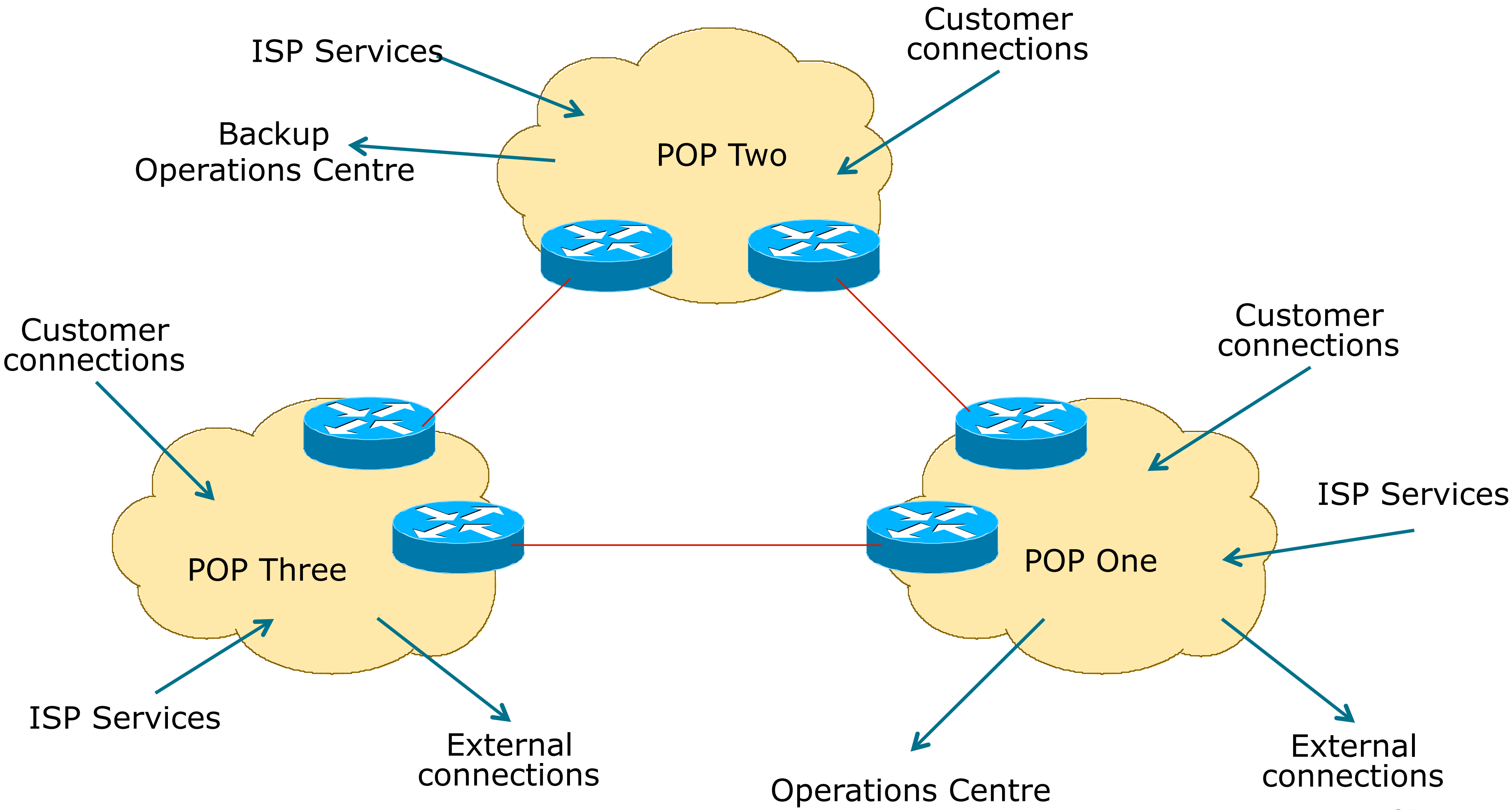
Backbone Design

- Routed Backbone
- Switched Backbone
  - ATM/Frame Relay core network
  - Now obsolete
- Point-to-point circuits
  - nx64K, T1/E1, T3/E3, OC3, OC12, GigE, OC48, 10GigE, OC192, OC768, 100GE
- ATM/Frame Relay service from telco
  - T3, OC3, OC12,… delivery
  - Easily upgradeable bandwidth (CIR)
  - Almost vanished in availability now

Distributed Network Design

- PoP design “standardised”
  - operational scalability and simplicity
- ISP essential services distributed around backbone
- NOC and “backup” NOC
- Redundant backbone links

Distributed Network Design



Backbone Links

- ATM/Frame Relay
  - Virtually disappeared due to overhead, extra equipment, and shared with other customers of the telco
  - MPLS has replaced ATM & FR as the telco favourite
- Leased Line/Circuit
  - Most popular with backbone providers
  - IP over Optics and Metro Ethernet very common in many parts of the world

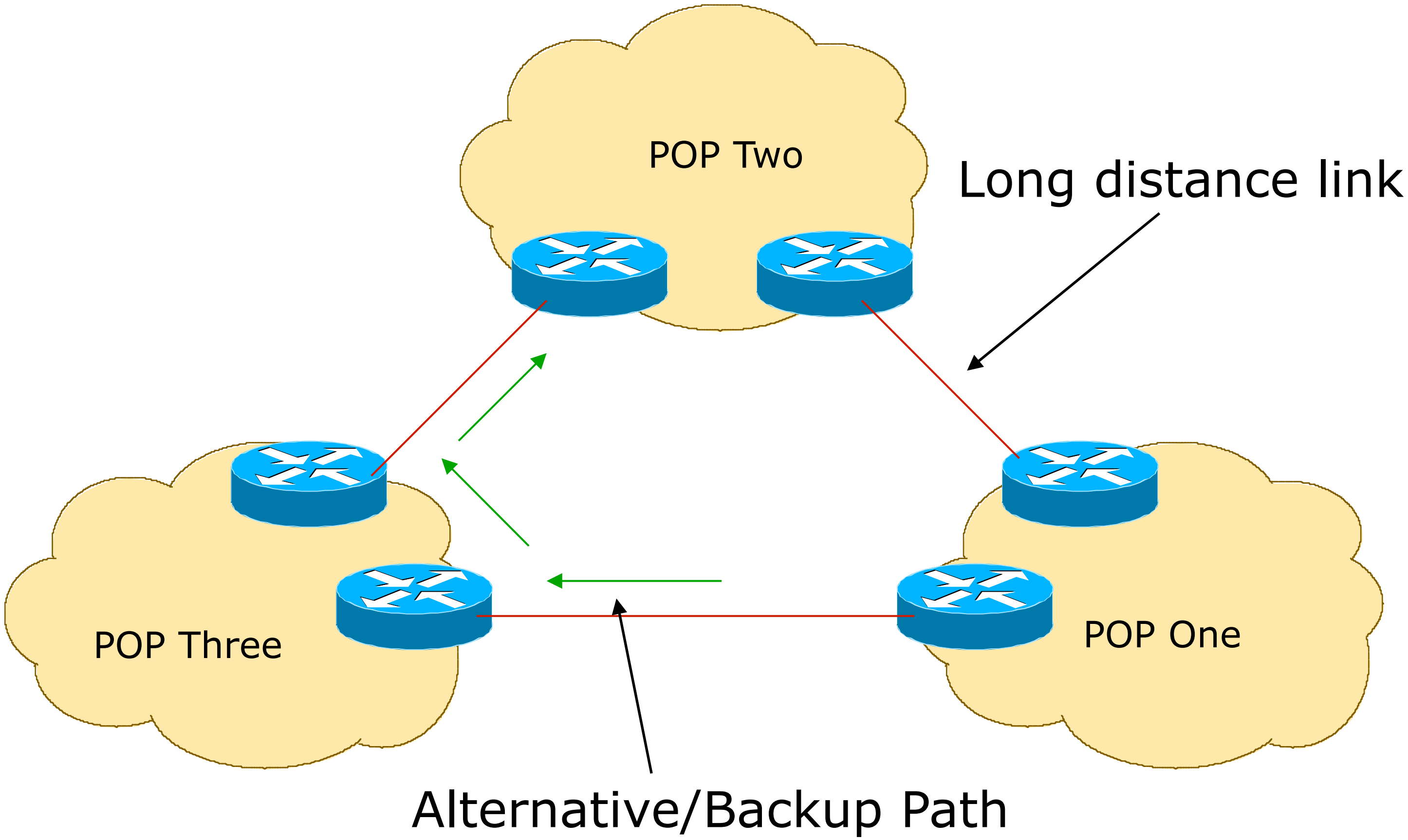
Long Distance Backbone Links

- These usually cost more
- Important to plan for the future
  - This means at least two years ahead
  - Stay in budget, stay realistic
  - Unplanned “emergency” upgrades will be disruptive without redundancy in the network infrastructure

Long Distance Backbone Links

- Allow sufficient capacity on alternative paths for failure situations
  - Sufficient can depend on the business strategy
  - Sufficient can be as little as 20%
  - Sufficient is usually over 50% as this offers “business continuity” for customers in the case of link failure
  - Some businesses choose 0%
    - Very short sighted, meaning they have no spare capacity at all!!

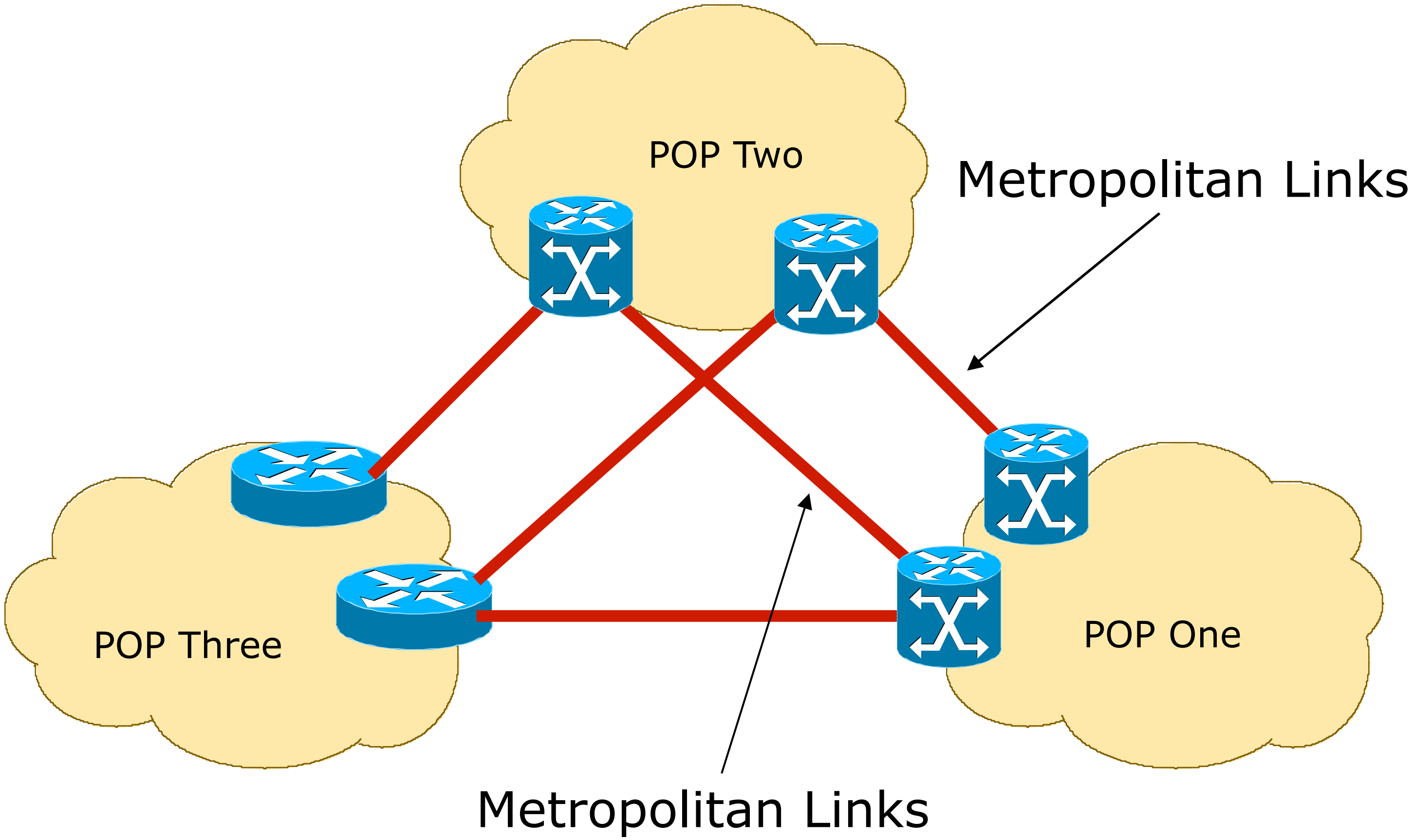
Long Distance Links



Metropolitan Area Backbone Links

- Tend to be cheaper
  - Circuit concentration
  - Choose from multiple suppliers
- Think big
  - More redundancy
  - Less impact of upgrades
  - Less impact of failures

Metropolitan Area Backbone Links



Traditional Point to Point Links

Upstream Connectivity and Peering

Transits

- Transit provider is another autonomous system which is used to provide the local network with access to other networks
  - Might be local or regional only
  - But more usually the whole Internet
- Transit providers need to be chosen wisely:
  - Only one
    - no redundancy
  - Too many
    - more difficult to load balance
    - no economy of scale (costs more per Mbps)
    - hard to provide service quality
- **Recommendation: at least two, no more than three**

Common Mistakes

- ISPs sign up with too many transit providers
  - Lots of small circuits (cost more per Mbps than larger ones)
  - Transit rates per Mbps reduce with increasing transit bandwidth purchased
  - Hard to implement reliable traffic engineering that doesn’t need daily fine tuning depending on customer activities
- No diversity
  - Chosen transit providers all reached over same satellite or same submarine cable
  - Chosen transit providers have poor onward transit and peering

Peers

- A peer is another autonomous system with which the local network has agreed to exchange locally sourced routes and traffic
- Private peer
  - Private link between two providers for the purpose of interconnecting
- Public peer
  - Internet Exchange Point, where providers meet and freely decide who they will interconnect with
- **Recommendation: peer as much as possible!**

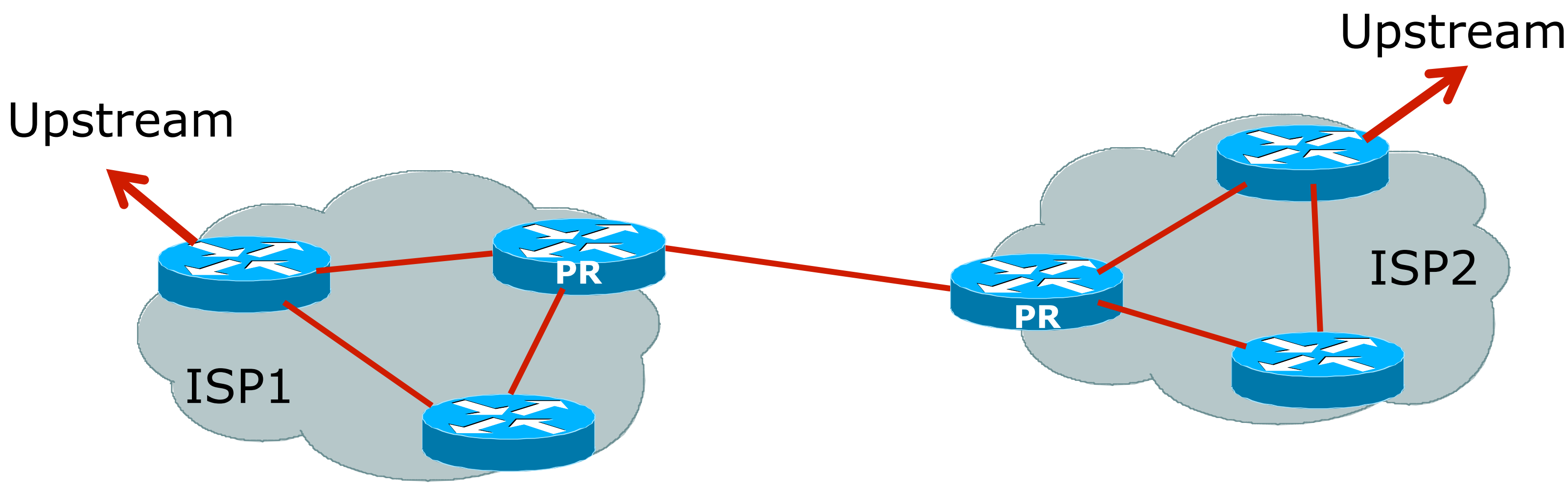
Common Mistakes

- Mistaking a transit provider’s “Exchange” business for a no-cost public peering point
- Not working hard to get as much peering as possible
  - Physically near a peering point (IXP) but not present at it
  - (Transit sometimes is cheaper than peering!!)
- Ignoring/avoiding competitors because they are competition
  - Even though potentially valuable peering partner to give customers a better experience

Private Interconnection

- Two service providers agree to interconnect their networks
  - They exchange prefixes they originate into the routing system (usually their aggregated address blocks)
  - They share the cost of the infrastructure to interconnect
    - Typically each paying half the cost of the link (be it circuit, satellite, microwave, fibre,…)
    - Connected to their respective peering routers
  - Peering routers only carry domestic prefixes

Private Interconnection

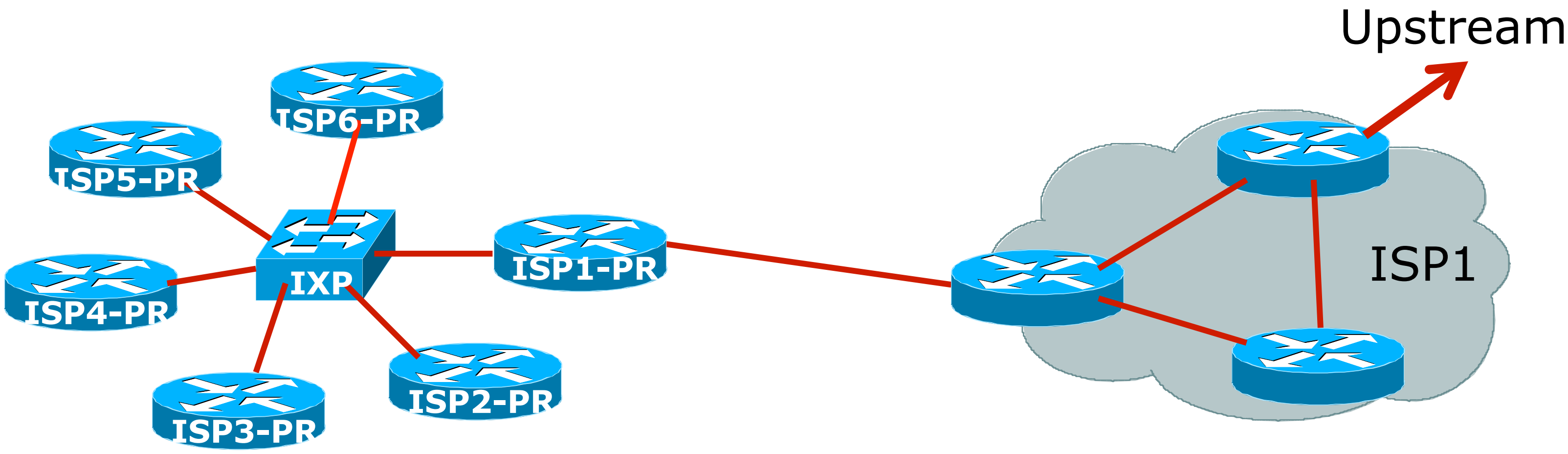


- PR = peering router
  - Runs iBGP (internal) and eBGP (with peer)
  - No default route
  - No "full BGP table"
  - Domestic prefixes only
- Peering router used for all private interconnects

Public Interconnection

- Service provider participates in an Internet Exchange Point
  - It exchanges prefixes it originates into the routing system with the participants of the IXP
  - It chooses who to peer with at the IXP
    - Bi-lateral peering (like private interconnect)
    - Multi-lateral peering (via IXP's route server)
  - It provides the router at the IXP and provides the connectivity from their PoP to the IXP
  - The IXP router carries only domestic prefixes

Public Interconnection

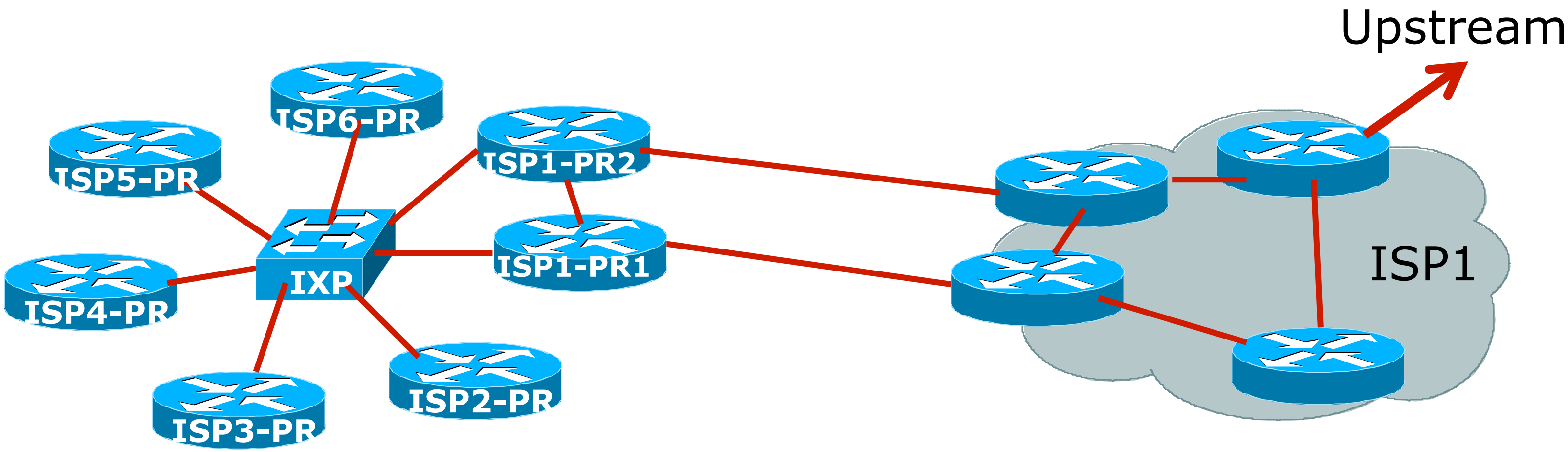


- ISP1-PR = peering router of our ISP
  - Runs iBGP (internal) and eBGP (with IXP peers)
  - No default route
  - No "full BGP table"
  - Domestic prefixes only
- Physically located at the IXP

Public Interconnection

- The ISP's router IXP peering router needs careful configuration:
  - It is remote from the domestic backbone
  - Should not originate any domestic prefixes
  - (As well as no default route, no full BGP table)
  - Filtering of BGP announcements from IXP peers (in and out)
- Provision of a second link to the IXP:
  - (for redundancy or extra capacity)
  - Usually means installing a second router
    - Connected to a second switch (if the IXP has two more more switches)
    - Interconnected with the original router (and part of iBGP mesh)

Public Interconnection

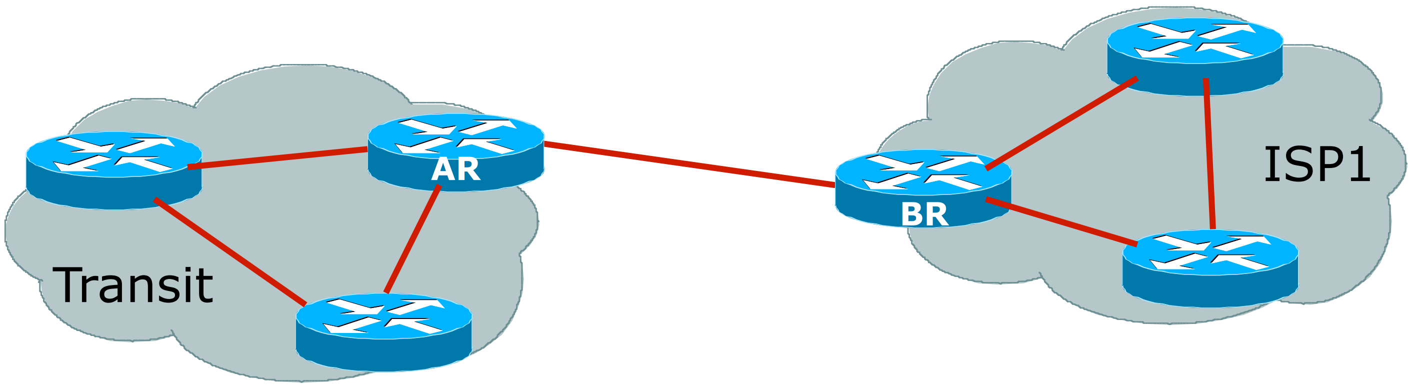


- Provision of a second link to the IXP means considering redundancy in the SP's backbone
  - Two routers
  - Two independent links
  - Separate switches (if IXP has two or more switches)

Upstream/Transit Connection

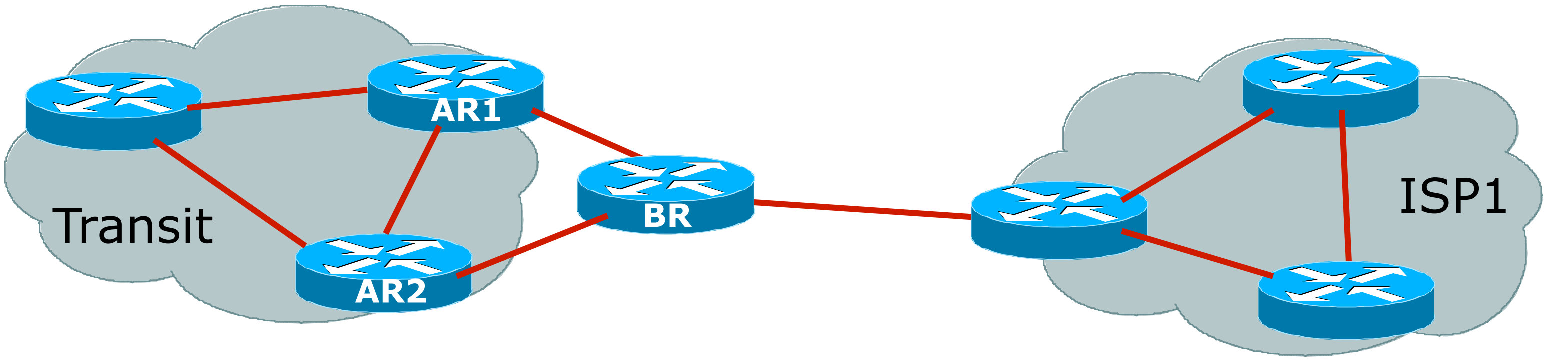
- Two scenarios:
  - Transit provider is in the locality
    - Which means bandwidth is cheap, plentiful, easy to provision, and easily upgraded
  - Transit provider is a long distance away
    - Over undersea cable, satellite, long-haul cross country fibre, etc
- Each scenario has different considerations which need to be accounted for

Local Transit Provider



- BR = ISP's Border Router
  - Runs iBGP (internal) and eBGP (with transit)
  - Either receives default route or the full BGP table from upstream
  - BGP policies are implemented here (depending on connectivity)
  - Packet filtering is implemented here (as required)

Distant Transit Provider



- BR = ISP’s Border Router
  - Co-located in a co-lo centre (typical) or in the upstream provider’s premises
  - Runs iBGP with rest of ISP1 backbone
  - Runs eBGP with transit provider router(s)
  - Implements BGP policies, packet filtering, etc
  - Does not originate any domestic prefixes

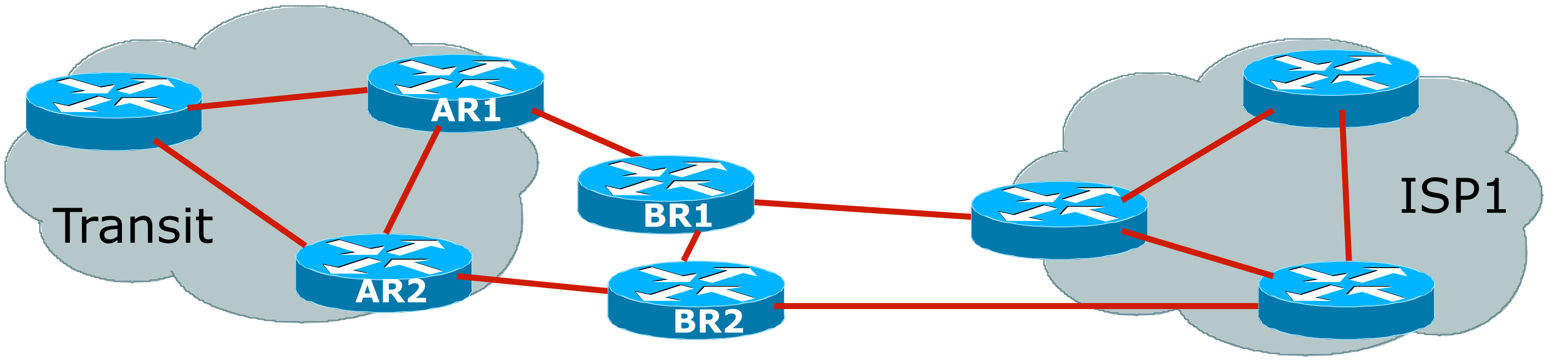
Distant Transit Provider

- Positioning a router close to the Transit Provider’s infrastructure is strongly encouraged:
  - Long haul circuits are expensive, so the router allows the ISP to implement appropriate filtering first
  - Moves the buffering problem away from the Transit provider
  - Remote co-lo allows the ISP to choose another transit provider and migrate connections with minimum downtime

Distant Transit Provider

- Other points to consider:
  - Does require remote hands support
  - (Remote hands would plug or unplug cables, power cycle equipment, replace equipment, etc as instructed)
  - Appropriate support contract from equipment vendor(s)
  - Sensible to consider two routers and two long-haul links for redundancy

Distant Transit Provider



- Upgrade scenario:
  - Provision two routers
  - Two independent circuits
  - Consider second transit provider and/or turning up at an IXP

Summary

- Design considerations for:
  - Private interconnects
    - Simple private peering
  - Public interconnects
    - Router co-lo at an IXP
  - Local transit provider
    - Simple upstream interconnect
  - Long distance transit provider
    - Router remote co-lo at datacentre or Transit premises

Upstream Connectivity and Peering Case Study

How Seacom chose their international peering locations and transit providers

Objective

- Obtain high grade Internet connectivity for the wholesale market in Africa to the rest of the world
- Emphasis on:
  - Reliability
  - Interconnectivity density
  - Scalability

Metrics Needed in Determining Solution (1)

- Focusing on operators that cover the destinations mostly required by Africa
  - i.e., English-speaking (Europe, North America)
- Include providers with good connectivity into South America and the Asia Pacific.
- Little need for providers who are strong in the Middle East, as demand from Africa for those regions is very, very low.

Metrics Needed in Determining Solution (2)

- Split the operators between Marseille (where the SEACOM cable lands) and London (where there is good Internet density)
  - To avoid outages due to backhaul failure across Europe
  - And still maintain good access to the Internet
- Look at providers who are of similar size so as not to fidget too much (or at all) with BGP tuning.
- The providers needed to support:
  - 10Gbps ports
  - Bursting bandwidth/billing
  - Future support for 100Gbps or N x 10Gbps

Metrics Needed in Determining Solution (3)

- Implement peering at major exchange points in Europe
  - To off-set long term operating costs re: upstream providers.

Implementing Solution

- Connected to Level(3) and GT-T (formerly Inteliquent, formerly Tinet) in Marseille
- Connected to NTT and TeliaSonera in London
- Peered in London (LINX)
- Peered in Amsterdam (AMS-IX)
- BGP setup to prefer traffic being exchanged at LINX and AMS-IX
- BGP setup to prefer traffic over the upstreams that we could not peer away
- No additional tuning done on either peered or transit traffic, i.e., no prepending, no de-aggregation, etc. All traffic setup to flow naturally

End Result

- 50% of traffic peered away in less than 2x months of peering at LINX and AMS-IX
- 50% of traffic handled by upstream providers
- Equal traffic being handled by Level(3) and GT-T in Marseille
- Equal traffic being handled by TeliaSonera and NTT in London
- Traffic distribution ratios across all the transit providers is some 1:1:0.9:0.9
- This has been steady state for the last 12x months
  - No BGP tuning has been done at all

Addressing

Where to get IP addresses and AS numbers

- Your upstream ISP
- Africa
  - AfriNIC – http://www.afrinic.net
- Asia and the Pacific
  - APNIC – http://www.apnic.net
- North America
  - ARIN – http://www.arin.net
- Latin America and the Caribbean
  - LACNIC – http://www.lacnic.net
- Europe and Middle East
  - RIPE NCC – http://www.ripe.net/info/ncc

Internet Registry Regions

Getting IP address space

- Take part of upstream ISP's PA space

  or

- Become a member of your Regional Internet Registry and get your own allocation
  - Require a plan for a year ahead
  - General policies are outlined in RFC2050, more specific details are on the individual RIR website
- There is no more IPv4 address space at IANA
  - APNIC and RIPE NCC are now in their "final /8" IPv4 delegation policy phase
  - Limited IPv4 available
  - IPv6 allocations are simple to get in most RIR regions

What about RFC1918 addressing?

- RFC1918 defines IPv4 addresses reserved for private Internets
  - Not to be used on Internet backbones
  - **http://www.ietf.org/rfc/rfc1918.txt**
- Commonly used within end-user networks
  - NAT used to translate from private internal to public external addressing
  - Allows the end-user network to migrate ISPs without a major internal renumbering exercise
- ISPs must filter RFC1918 addressing at their network edge
  - **http://www.cymru.com/Documents/bogon-list.html**

What about RFC1918 addressing?

- There is a long list of well known problems:
  - http://www.rfc-editor.org/rfc/rfc6752.txt
- Including:
  - False belief it conserves address space
  - Adverse effects on Traceroute
  - Effects on Path MTU Discovery
  - Unexpected interactions with some NAT implementations
  - Interactions with edge anti-spoofing techniques
  - Peering using loopbacks
  - Adverse DNS Interaction
  - Serious Operational and Troubleshooting issues
  - Security Issues
    - false sense of security, defeating existing security techniques

Private versus Globally Routable IP Addressing

- Infrastructure Security: not improved by using private addressing
  - Still can be attacked from inside, or from customers, or by reflection techniques from the outside
- Troubleshooting: made an order of magnitude harder
  - No Internet view from routers
  - Other ISPs cannot distinguish between down and broken
- Summary:
  - ALWAYS use globally routable IP addressing for ISP Infrastructure

Addressing Plans – ISP Infrastructure

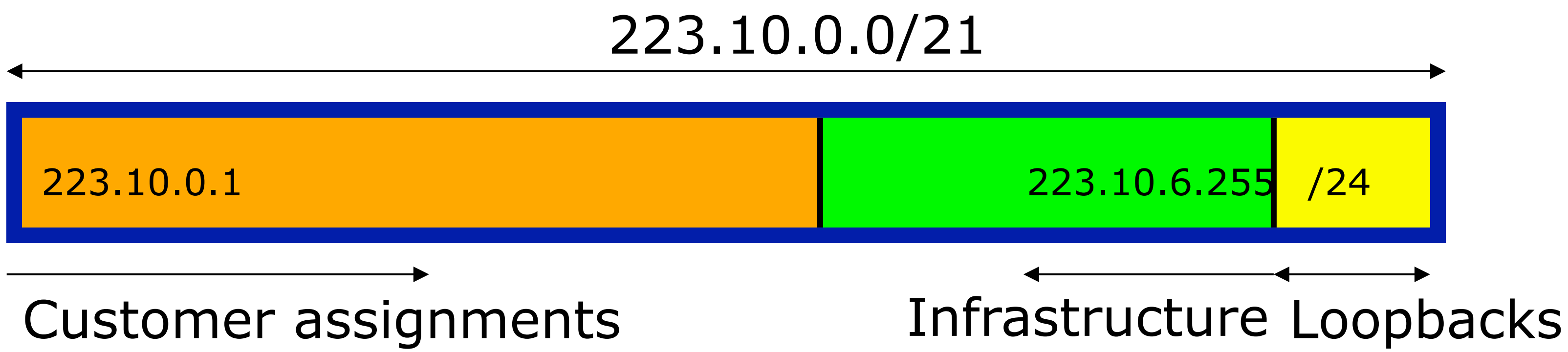
- Address block for router loop-back interfaces
- Address block for infrastructure
  - Per PoP or whole backbone
  - Summarise between sites if it makes sense
  - Allocate according to genuine requirements, not historic classful boundaries
- Similar allocation policies should be used for IPv6 as well
  - ISPs just get a substantially larger block (relatively) so assignments within the backbone are easier to make

Addressing Plans – Customer

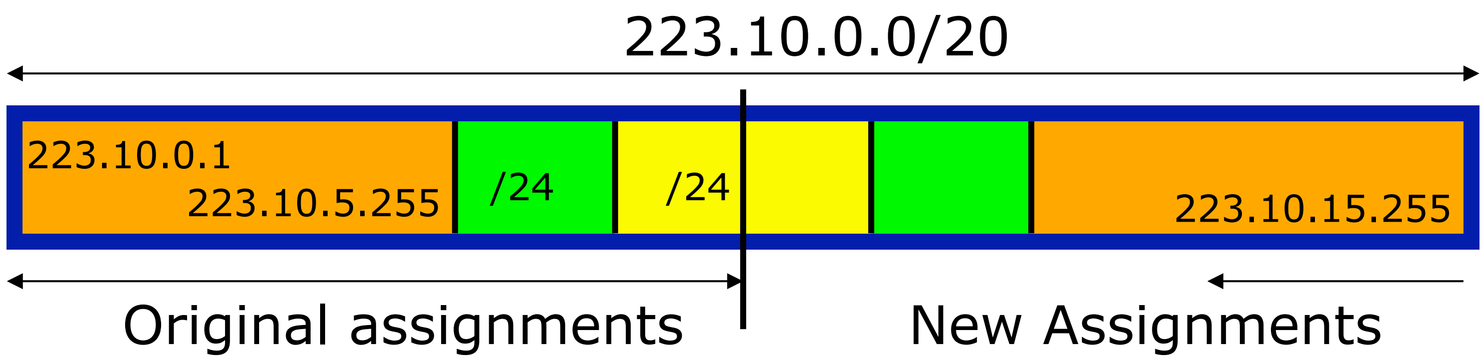
- Customers are assigned address space according to need
- Should not be reserved or assigned on a per PoP basis
  - ISP iBGP carries customer nets
  - Aggregation not required and usually not desirable

Addressing Plans – ISP Infrastructure

- Phase One



- Phase Two



Addressing Plans Planning

- Registries will usually allocate the next block to be contiguous with the first allocation
  - Minimum allocation could be /21
  - Very likely that subsequent allocation will make this up to a /20
  - So plan accordingly

Addressing Plans (contd)

- Document infrastructure allocation
  - Eases operation, debugging and management
- Document customer allocation
  - Contained in iBGP
  - Eases operation, debugging and management
  - Submit network object to RIR Database

Routing Protocols

Routing Protocols

- IGP – Interior Gateway Protocol
  - Carries infrastructure addresses, point-to-point links
  - Examples are OSPF, ISIS,...
- EGP – Exterior Gateway Protocol
  - Carries customer prefixes and Internet routes
  - Current EGP is BGP version 4
- No connection between IGP and EGP

Why Do We Need an IGP?

- ISP backbone scaling
  - Hierarchy
  - Modular infrastructure construction
  - Limiting scope of failure
  - Healing of infrastructure faults using dynamic routing with fast convergence

Why Do We Need an EGP?

- Scaling to large network
  - Hierarchy
  - Limit scope of failure
- Policy
  - Control reachability to prefixes
  - Merge separate organizations
  - Connect multiple IGPs

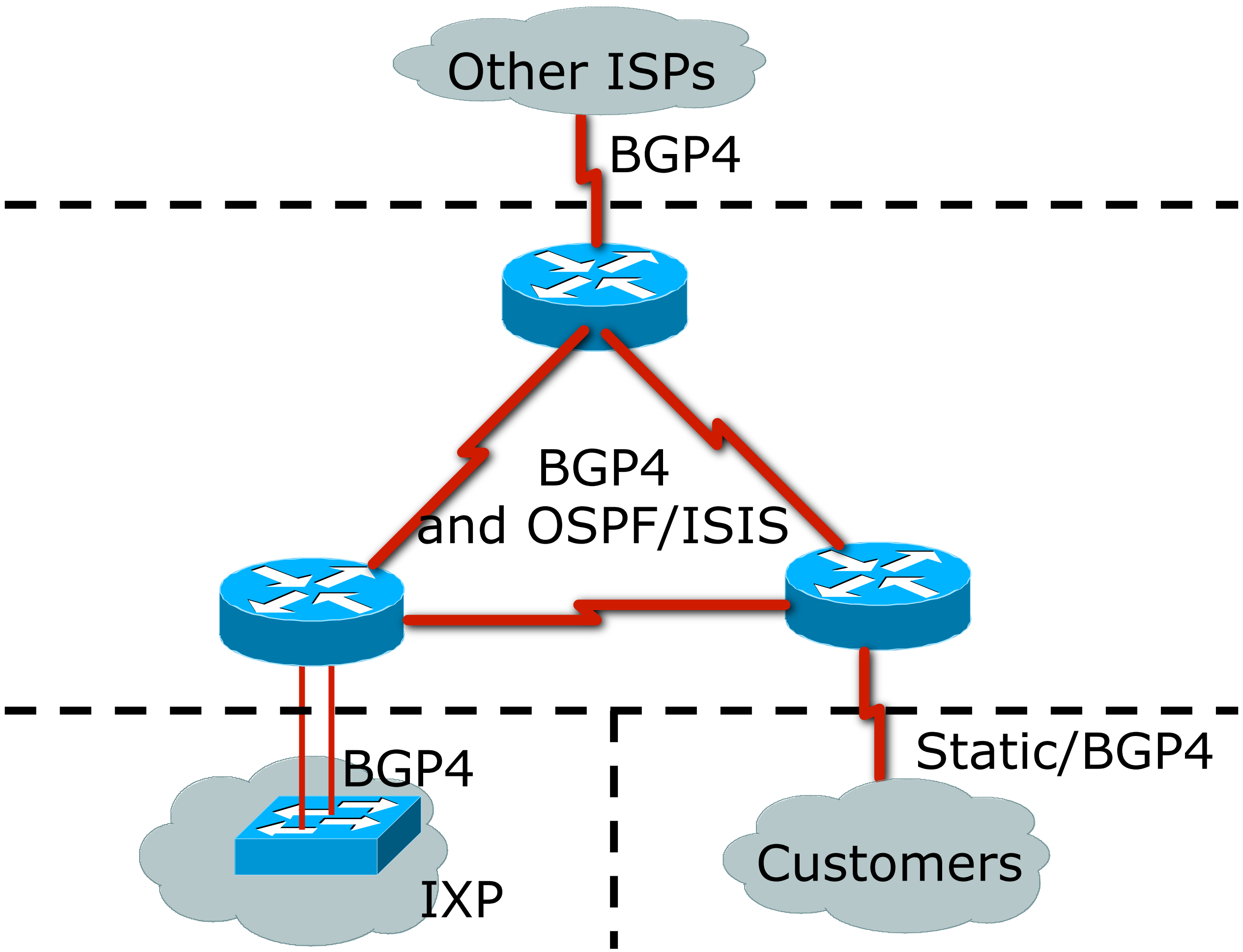
Interior versus Exterior Routing Protocols

- Interior
  - Automatic neighbour discovery
  - Generally trust your IGP routers
  - Prefixes go to all IGP routers
  - Binds routers in one AS together
- Exterior
  - Specifically configured peers
  - Connecting with outside networks
  - Set administrative boundaries
  - Binds AS's together

Interior versus Exterior Routing Protocols

- Interior
  - Carries ISP infrastructure addresses only
  - ISPs aim to keep the IGP small for efficiency and scalability
- Exterior
  - Carries customer prefixes
  - Carries Internet prefixes
  - EGPs are independent of ISP network topology

Hierarchy of Routing Protocols



Routing Protocols: Choosing an IGP

- OSPF and ISIS have very similar properties
  - Review the "ISIS vs OSPF" presentation
- Which to choose?
  - Choose which is appropriate for your operators' experience
  - In most vendor releases, both OSPF and ISIS have sufficient "nerd knobs" to tweak the IGP's behaviour
  - OSPF runs on IP
  - ISIS runs on infrastructure, alongside IP
  - ISIS supports both IPv4 and IPv6
  - OSPFv2 (IPv4) plus OSPFv3 (IPv6)

Routing Protocols: IGP Recommendations

- Keep the IGP routing table as small as possible
  - If you can count the routers and the point-to-point links in the backbone, that total is the number of IGP entries you should see
- IGP details:
  - Should only have router loopbacks, backbone WAN point-to-point link addresses, and network addresses of any LANs having an IGP running on them
  - Strongly recommended to use inter-router authentication
  - Use inter-area summarisation if possible

Routing Protocols: More IGP recommendations

- To fine tune IGP table size more, consider:
  - Using "ip unnumbered" on customer point-to-point links – saves carrying that /30 in IGP
    - (If customer point-to-point /30 is required for monitoring purposes, then put this in iBGP)
  - Use contiguous addresses for backbone WAN links in each area – then summarise into backbone area
  - Don't summarise router loopback addresses – as iBGP needs those (for next-hop)
  - Use iBGP for carrying anything which does not contribute to the IGP Routing process

Routing Protocols: iBGP Recommendations

- iBGP should carry everything which doesn’t contribute to the IGP routing process
  - Internet routing table
  - Customer assigned addresses
  - Customer point-to-point links
  - Access network dynamic address pools, passive LANs, etc

Routing Protocols: More iBGP Recommendations

- Scalable iBGP features:
  - Use neighbour authentication
  - Use peer-groups to speed update process and for configuration efficiency
  - Use communities for ease of filtering
  - Use route-reflector hierarchy
    - Route reflector pair per PoP (overlaid clusters)

Security

Security

- ISP Infrastructure security
- ISP Network security
- Security is not optional!
- ISPs need to:
  - Protect themselves
  - Help protect their customers from the Internet
  - Protect the Internet from their customers
- The following slides are general recommendations
  - Do more research on security before deploying any network

ISP Infrastructure Security

- Router & Switch Security
  - Use Secure Shell (SSH) for device access & management
    - Do NOT use Telnet
  - Device management access filters should only allow NOC and device-to-device access
    - Do NOT allow external access
  - Use TACACS+ for user authentication and authorisation
    - Do NOT create user accounts on routers/switches

ISP Infrastructure Security

- Remote access
  - For Operations Engineers who need access while not in the NOC
  - Create an SSH server host (this is all it does)
    - Or a Secure VPN access server
  - Ops Engineers connect here, and then they can access the NOC and network devices

ISP Infrastructure Security

- Other network devices?
  - These probably do not have sophisticated security techniques like routers or switches do
  - Protect them at the LAN or point-to-point ingress (on router)
- Servers and Services?
  - Protect servers on the LAN interface on the router
  - Consider using iptables &c on the servers too
- SNMP
  - Apply access-list to the SNMP ports
  - Should only be accessible by management system, not the world

ISP Infrastructure Security

- General Advice:
  - Routers, Switches and other network devices should not be contactable from outside the AS
  - Achieved by blocking typical management access protocols for the infrastructure address block at the network perimeter
    - E.g. ssh, telnet, http, snmp,…
  - Use the ICSI Netalyser to check access levels:
    - http://netalyzr.icsi.berkeley.edu
  - **Don't block everything: BGP, traceroute and ICMP still need to work!**

ISP Network Security

- Effective filtering
  - Protect network borders from "traffic which should not be on the public Internet", for example:
    - LAN protocols (eg netbios)
    - Well known exploit ports (used by worms and viruses)
    - Drop traffic arriving and going to private and non-routable address space (IPv4 and IPv6)
  - Achieved by packet filters on border routers
    - Remote trigger blackhole filtering

ISP Network Security – RTBF

- Remote trigger blackhole filtering
  - ISP NOC injects prefixes which should not be accessible across the AS into the iBGP
  - Prefixes have next hop pointing to a blackhole address
  - All iBGP speaking backbone routers configured to point the blackhole address to the null interface
  - Traffic destined to these blackhole prefixes are dropped by the first router they reach
- Application:
  - Any prefixes (including RFC1918) which should not have routability across the ISP backbone

ISP Network Security – RTBF

- Remote trigger blackhole filtering example:
  - Origin router:

```
router bgp 64509
  redistribute static route-map black-hole-trigger
!
ip route 10.5.1.3 255.255.255.255 Null0 tag 66
!
route-map black-hole-trigger permit 10
 match tag 66
 set local-preference 1000
 set community no-export
 set ip next-hop 192.0.2.1
!
```

  - iBGP speaking backbone router:

```
ip route 192.0.2.1 255.255.255.255 null0
```

ISP Network Security – RTBF

- Resulting routing table entries:

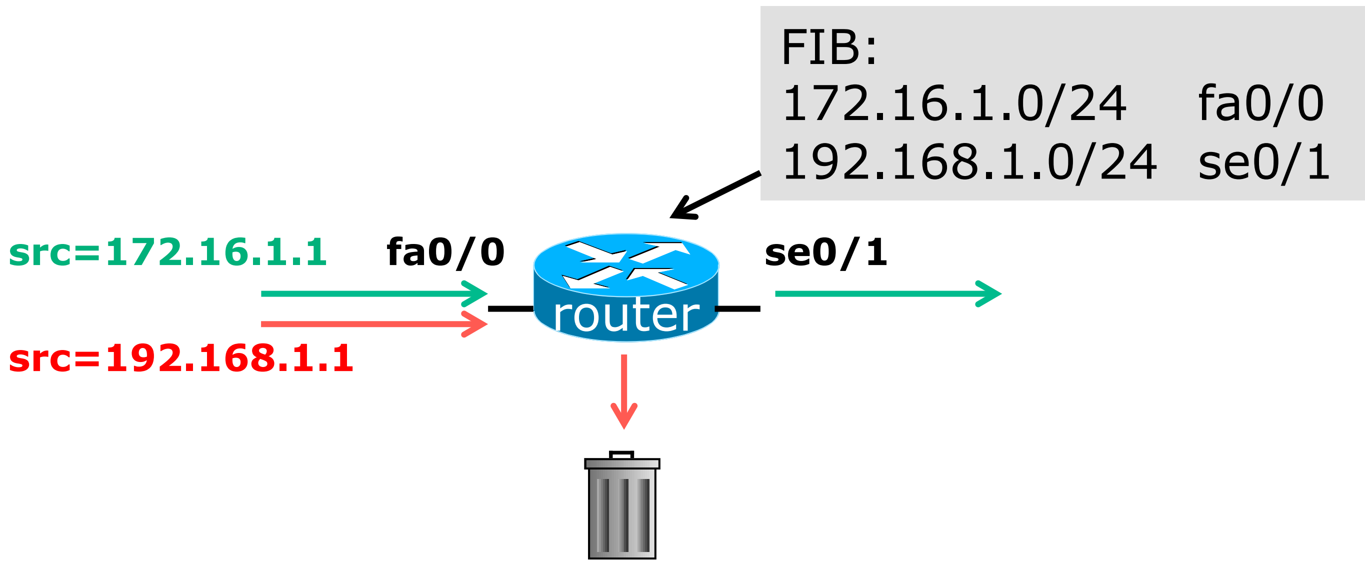
```
gw1#sh ip bgp 10.5.1.3
BGP routing table entry for 10.5.1.3/32, version 64572219
Paths: (1 available, best #1, table Default-IP-Routing-Table)
  Not advertised to any peer
  Local
    192.0.2.1 from 1.1.10.10 (1.1.10.10)
      Origin IGP, metric 0, localpref 1000, valid, internal, best
      Community: no-export

gw1#sh ip route 10.5.1.3
Routing entry for 10.5.1.3/32
  Known via "bgp 64509", distance 200, metric 0, type internal
  Last update from 192.0.2.1 00:04:52 ago
  Routing Descriptor Blocks:
  * 192.0.2.1, from 1.1.10.10, 00:04:52 ago
      Route metric is 0, traffic share count is 1
      AS Hops 0
```

ISP Network Security – uRPF

- Unicast Reverse Path Forwarding
- Strongly recommended to be used on all customer facing **static** interfaces
  - BCP 38 (tools.**ietf**.org/html/**bcp38*)***
  - **Blocks all unroutable source addresses the customer may be using**
  - Inexpensive way of filtering customer's connection (when compared with packet filters)
- Can be used for multihomed connections too, but extreme care required

What is uRPF?



- Router compares source address of incoming packet with FIB entry
  - If FIB entry interface matches incoming interface, the packet is forwarded
  - If FIB entry interface does not match incoming interface, the packet is dropped

Security Summary

- Implement RTBF
  - Inside ISP backbone
  - Make it available to BGP customers too
    - They can send you the prefix you need to block with a special community attached
    - You match on that community, and set the next-hop to the null address
- Implement uRPF
  - For all static customers
- Use SSH for device access
- Use TACACS+ for authentication

Out of Band Management

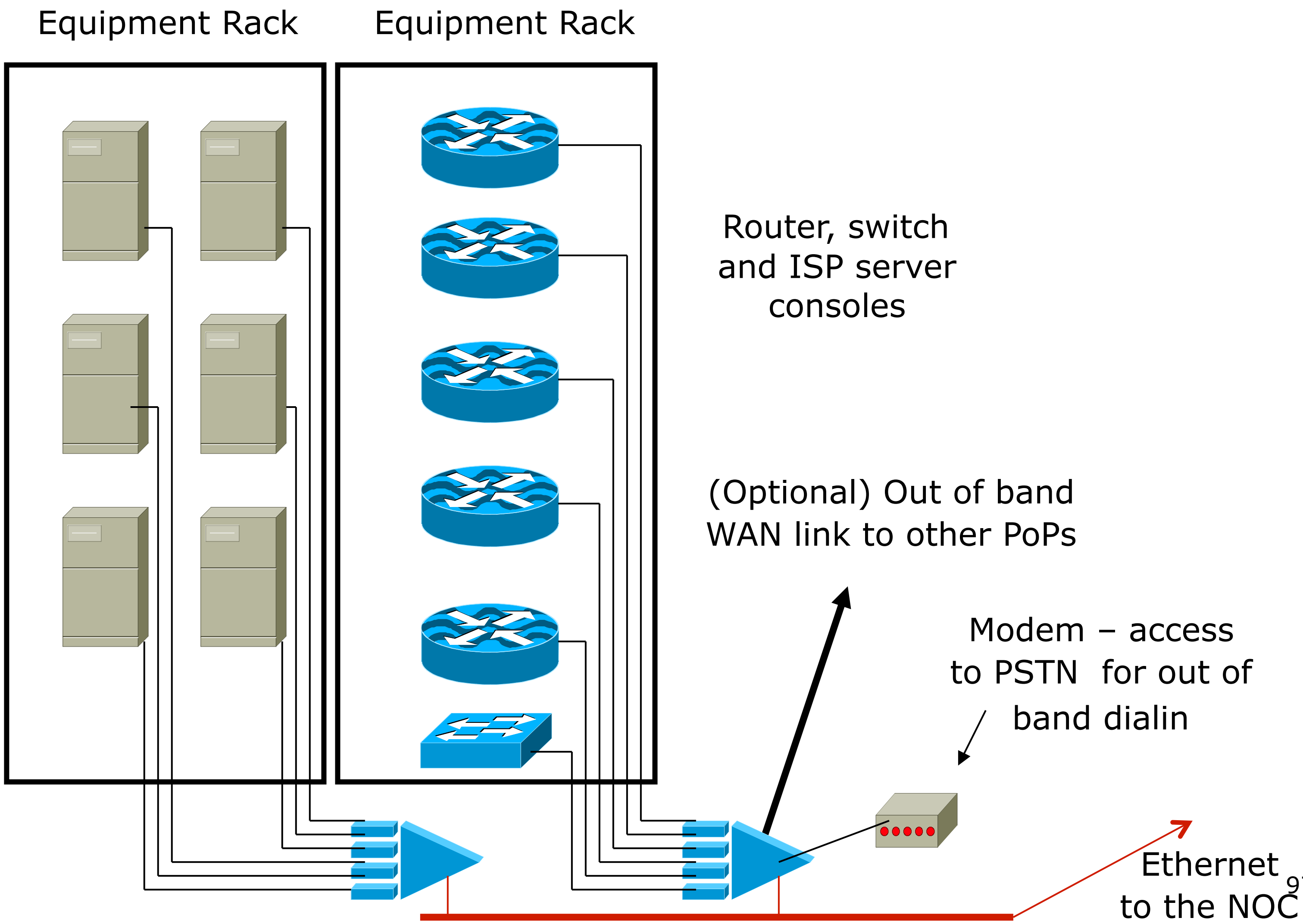
Out of Band Management

- **Not optional!**
- Allows access to network equipment in times of failure
- Ensures quality of service to customers
  - Minimises downtime
  - Minimises repair time
  - Eases diagnostics and debugging

Out of Band Management

- OoB Example – Access server:
  - modem attached to allow NOC dial in
  - console ports of all network equipment connected to serial ports
  - LAN and/or WAN link connects to network core, or via separate management link to NOC
- Full remote control access under all circumstances

Out of Band Network



Out of Band Management

- OoB Example – Statistics gathering:
  - Routers are NetFlow and syslog enabled
  - Management data is congestion/failure sensitive
  - Ensures management data integrity in case of failure
- Full remote information under all circumstances

Test Laboratory

Test Laboratory

- Designed to look like a typical PoP
  - Operated like a typical PoP
- Used to trial new services or new software under realistic conditions
- Allows discovery and fixing of potential problems before they are introduced to the network

Test Laboratory

- Some ISPs dedicate equipment to the lab
- Other ISPs “purchase ahead” so that today’s lab equipment becomes tomorrow’s PoP equipment
- Other ISPs use lab equipment for “hot spares” in the event of hardware failure

Test Laboratory

- Can't afford a test lab?
  - Set aside one spare router and server to trial new services
  - Never ever try out new hardware, software or services on the live network
- Every major ISP in the US and Europe has a test lab
  - It's a serious consideration

Operational Considerations

Operational Considerations

Why design the world's best network when you have not thought about what operational good practices should be implemented?

Operational Considerations Maintenance

- Never work on the live network, no matter how trivial the modification may seem
  - Establish maintenance periods which your customers are aware of
    - e.g. Tuesday 4-7am, Thursday 4-7am
- Never do maintenance on the last working day before the weekend
  - Unless you want to work all weekend cleaning up
- Never do maintenance on the first working day after the weekend
  - Unless you want to work all weekend preparing

Operational Considerations Support

- Differentiate between customer support and the Network Operations Centre
  - Customer support fixes customer problems
  - NOC deals with and fixes backbone and Internet related problems
- Network Engineering team is last resort
  - They design the next generation network, improve the routing design, implement new services, etc
  - They do not and should not be doing support!

Operational Considerations NOC Communications

- NOC should know contact details for equivalent NOCs in upstream providers and peers
- Or consider joining the INOC-DBA system
  - Voice over IP phone system using SIP
  - Runs over the Internet
  - www.pch.net/inoc-dba for more information

ISP Network Design

Summary

ISP Design Summary

- KEEP IT SIMPLE & STUPID ! (KISS)
- Simple is elegant is scalable
- Use Redundancy, Security, and Technology to make life easier for yourself
- Above all, ensure quality of service for your customers

ISP Network Design

ISP Workshops