Atlantic Wave Architecture

Overview for the Joint Engineering Team

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MAX

Atlantic Wave Objectives

- **A-Wave is an <u>International</u> Peering Fabric**
  - **US, Canada, Europe, South America**
  - **Distributed IP peering points:**
    - NYC, WDC, ATL, MIA, SPB
- **A-Wave is an integral part of International Research Networks Connections program (NSF)**
- **A-Wave provides multi-layer/multi-protocol services between participating networks:**
  - **Layer 3 peering services over ethernet**
  - **GLIF "light path" services**
  - **Others TBD**

IP Peering/Exchange Services over A-Wave

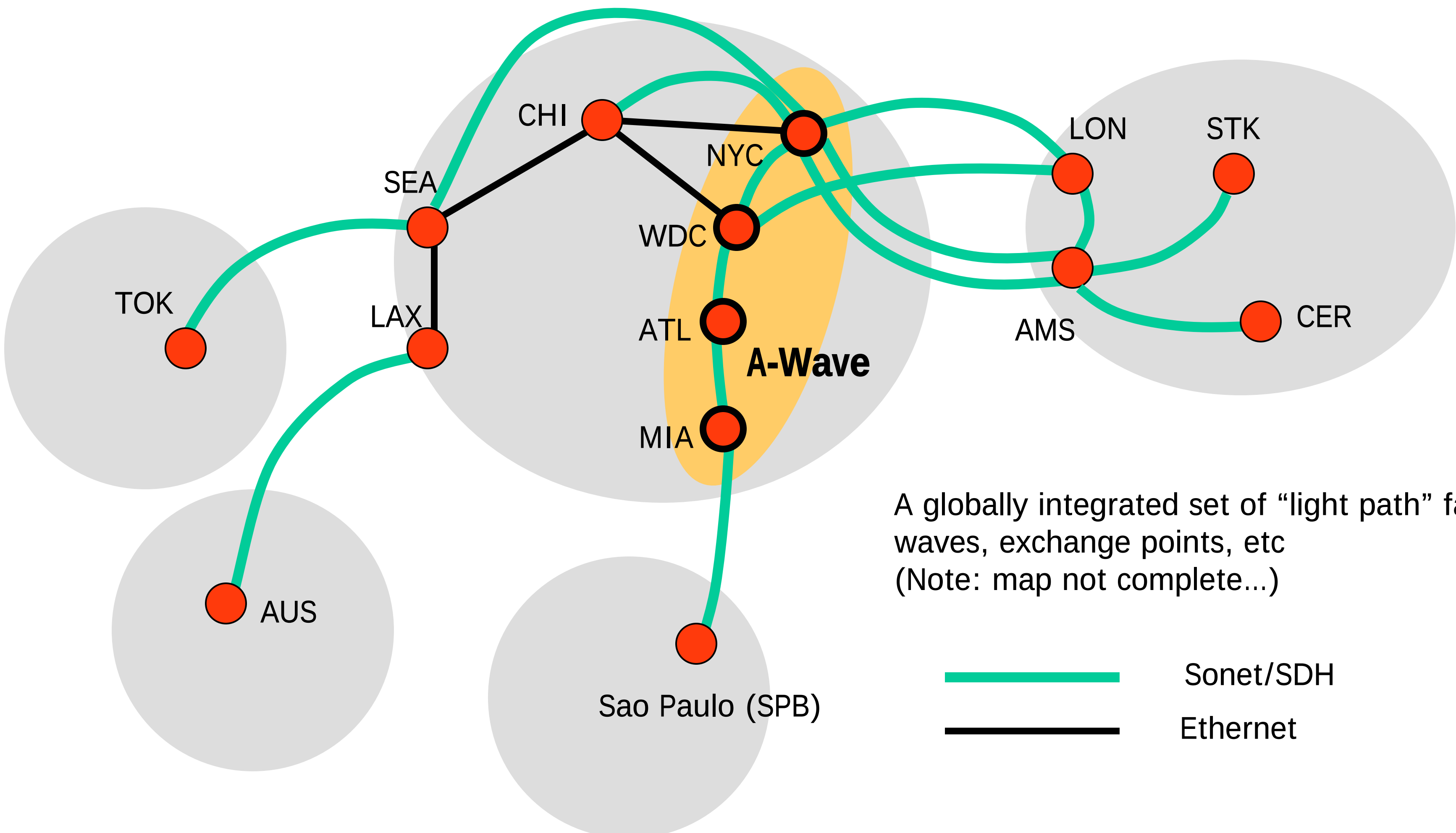
- **A-Wave must provide a Layer 3 distributed exchange capability:**
  - **Ethernet based**
    - Best effort packet transit between peering networks
    - Linear topology – A-Wave has a single unprotected NLR wave
    - 1 GE, 10GE LAN, 10GE WAN client access
    - Jumbo frame support
  - **Minimum VLAN requirements (see Pacific Wave architecture):**
    - A single VLAN (broadcast domain) allows each attached network to establish their peerings directly with the other attached networks
      - No requirement for a layer3 transit ASN
      - Requires fewer "man in the middle" cycles to establish VLANs for each peering pair
    - VLANs are used primarily to constrain broadcast traffic
      - Reduce amount of extraneous traffic consuming inter-switch capacity

“GLIF” Services across A-Wave

- **Atlantic Wave is a key component of international R&E networking**
  - **Europe, US, and Canada meet in NYC**
  - **US and South America in MIA .**
  - **A-Wave provides the US transit between these exchange points**
- **These communities will be looking for GLIF capabilities over these inter-continental links**
- **A-Wave needs to be part of the service fabric that being deployed between these regions:**
  - **Sonet/SDH between Europe and North America (NYC/WDC)**
  - **Sonet/SDH between South America and US**
  - **Sonet/SDH between South America and Europe**
  - **Sonet/SDH between Canada and US exchange points**
  - **Ethernet is becoming much more common for layer3 best-effort peering between routers and for end system interfaces into “GLIF” service environments**
  - **Future architectures will be exploring other framing capabilities e.g. infiniband**

However, the Global telecommunications fabic is (and is expected to continue to be) Sonet/SDH based

The Strategic Picture…



A globally integrated set of “light path” facilities: waves, exchange points, etc
(Note: map not complete…)

Long Term Approach

- **Trans-continental links are all Sonet/SDH**
- **End systems are requesting ethernet, sonet, and potentially other framing protocols over life of project**
- **Sonet's deterministic qualities, next gen features, and global deployment make it very attractive as a lowest common denominator for global services**

- **A-Wave plans to deploy next gen Sonet/SDH along the east coast US as a foundation for the international common services we anticipate**
  - **This will be Phase 2 – timed to coordinate with availability of more mature Next Gen Sonet switching gear and advanced control plane capabilities, and in conjunction with additonal GLIF capable inter-contenintal links.**

Why a Sonet Backbone for A-Wave?

- **Next Generation Sonet/SDH**
  - **Generic Framing Protocol - GFP (ITU-T G.7041)**
    - Allows efficient mapping of layer 2 (Ethernet) protocols to the synchronous payloads of sonet
      - GFP-F maps ethernet frames to the sonet payloads
      - GFP-T transparently maps the physical layer ethernet into sonet
      - Other layer2 framing protocols supported as well
  - **Virtual Concatenation - VCAT (ITU-T G.707)**
    - Efficient allocation of sonet frames to Virtual Container Groups (I.e. circuits)
  - **Link Capacity Adjustment Scheme - LCAS (ITU-T G.7042)**
    - Allows hitless circuit adjustments (increase/decrease capacity, grooming to new paths on the fly, etc.)

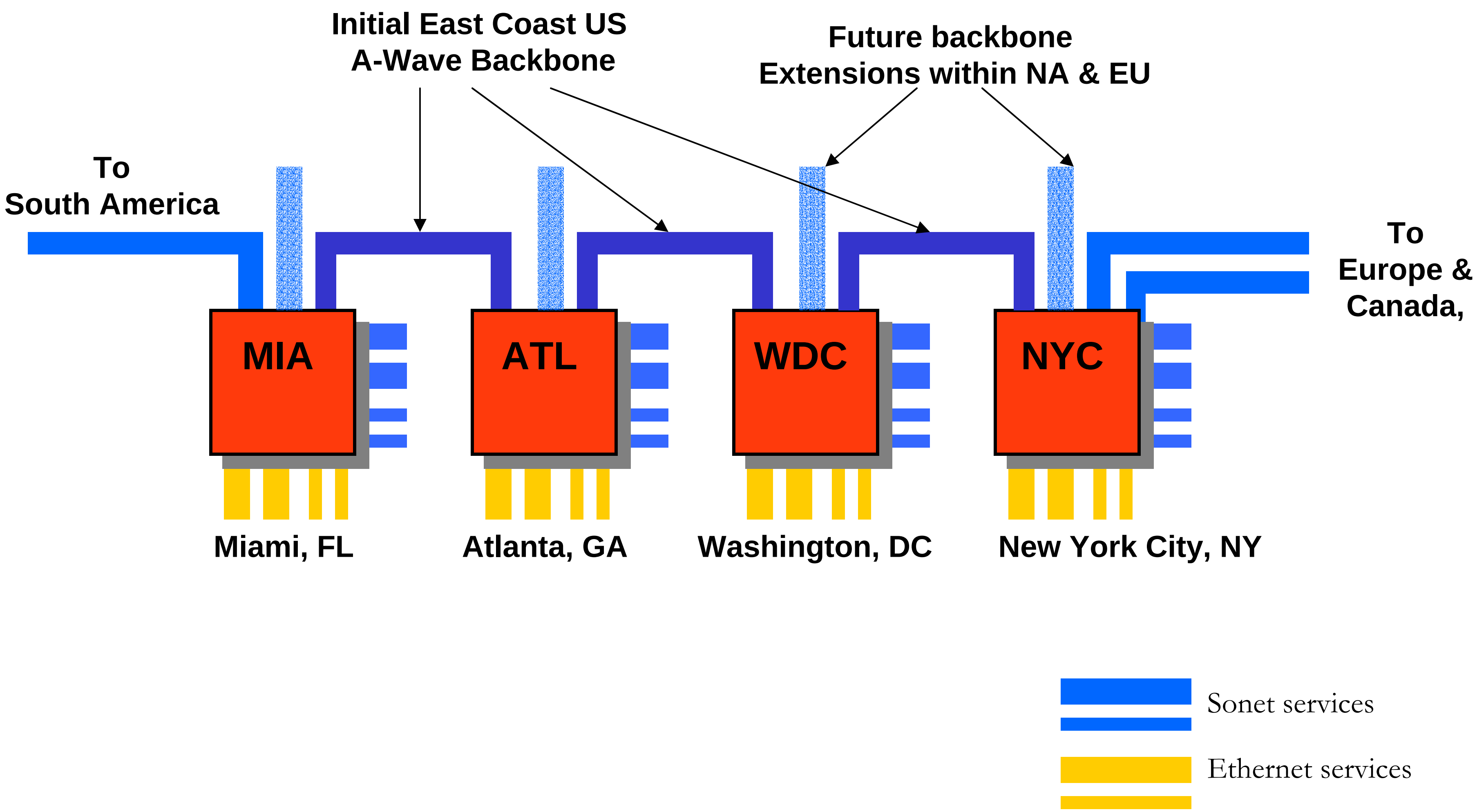
Why a Sonet Backbone for A-Wave?

- **This is "SuperSonet" - using next-gen sonet standards…**
  - **New Sonet/SDH still provides traditional features:**
    - deterministic and repeatable performance
    - very predictable and "hard" service segregation
  - **New Sonet features provide capabilities not present in other framing technologies:**
    - Synchronous multi-path load sharing, and capacity allocation
    - On-the-fly capacity adjustments for grooming and "soft" failover
    - Capacity granularity of 51Mbs
    - Standardized protocol encapsulation standards (GFP)
  - **New Sonet/SDH capabilities are edge functions and are compatible with existing sonet/sdh infrastructure**
    - I.e. the R&E community can employ commercial services [where necessary and/or economic] to carry superSonet enabled light paths – including ethernet services, packet over sonet, infiniband, fiber channel, etc.

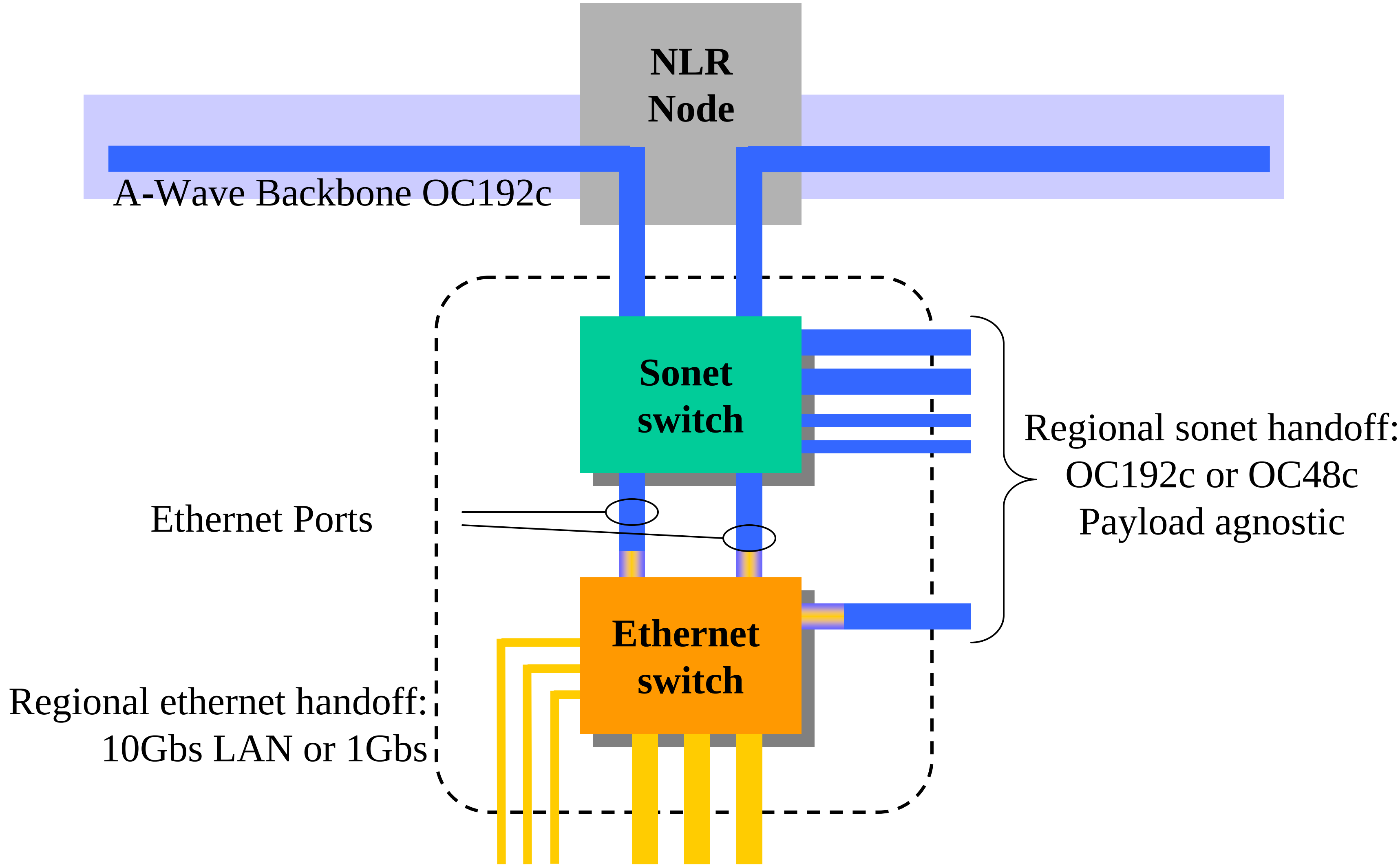
Why a Sonet Backbone for A-Wave?

- **Compatibility with existing network links**
  - **The vast majority of international links (all?) are presented at the exchange points as Sonet.**
    - Trans-oceanic links are all Sonet/SDH (IEEAF OC192, EuroLink OC192, NetherLight, South America, Japan and Australia…)
    - Canadian links are Sonet
    - Commercial services are [still] mostly Sonet or SDH
  - **With a superSonet framed backbone, A-Wave can transit VCG light paths directly from the inbound Sonet circuit to the outbound sonet VCGs without adding [unnecessary] decap/encap steps & cost, without inserting [unnecessary and poorly understood] switch buffering, and preserving the synchronous and deterministic flow characteristics across the core.**
  - **Some such links may require re-configuration**
    - E.g. OC192c reconfigured to 4x OC48c, OC48c to 2x GFP-F GbE
    - Or: OC192c front ended with VCAT/LCAS capable switching gear
- **$$$ New generation of Sonet/SDH switches and DWDM optical gear are no more expensive than Ethernet**
  - **Most 10Gbs transponders/tranceivers for DWDM applications are “UNI PHY” – I.e. software configurable for LAN, WAN, or Sonet service – so the cost is the same.**
  - **Most of the major manufactures are already offering either rate selectable 2R transponders or GFP encap/decap of 1GbE for 2.5 Gbs interfaces**
  - **Note: integrated Sonet/Ethernet switches are just now reaching the market.**

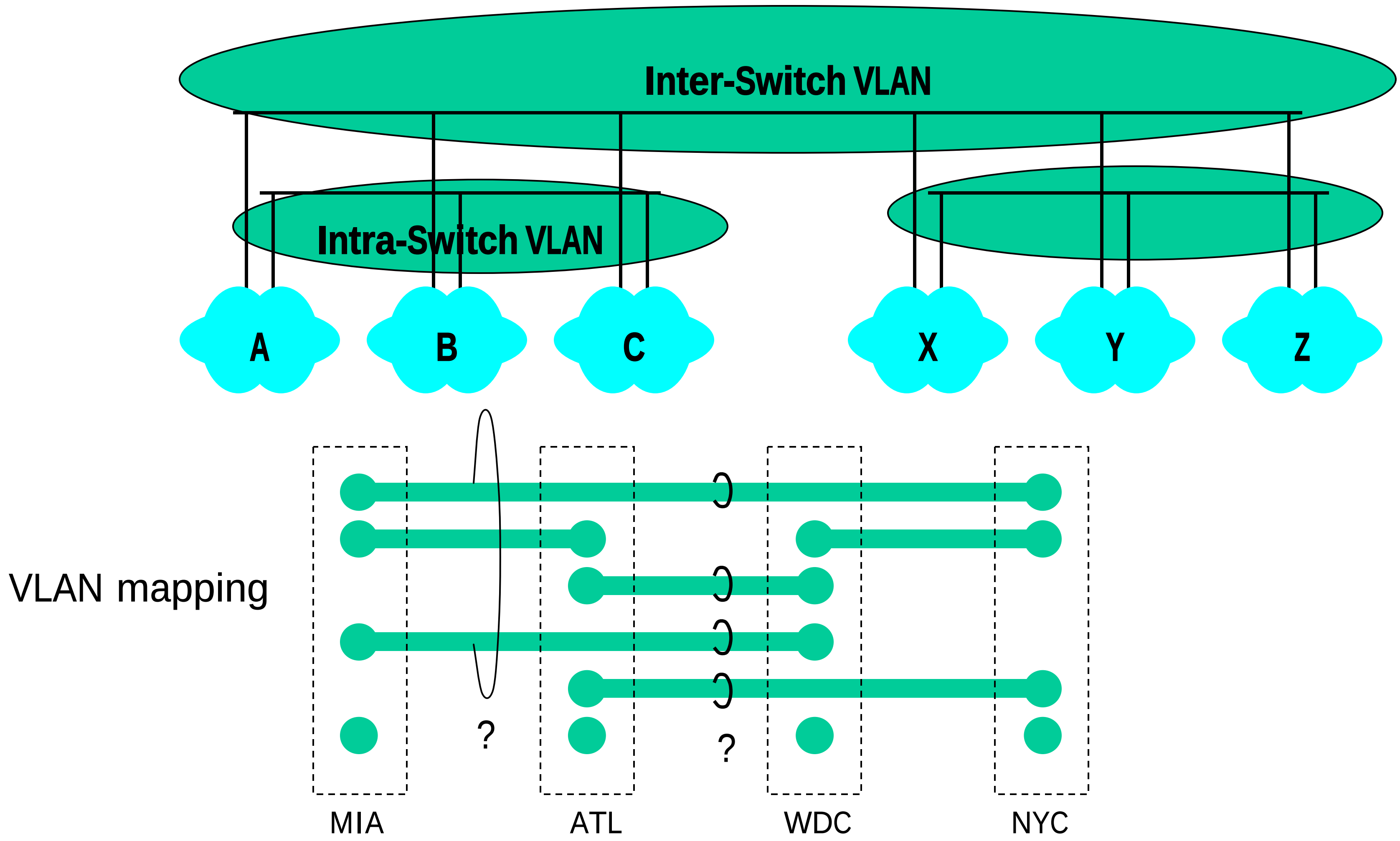
Atlantic Wave Topology



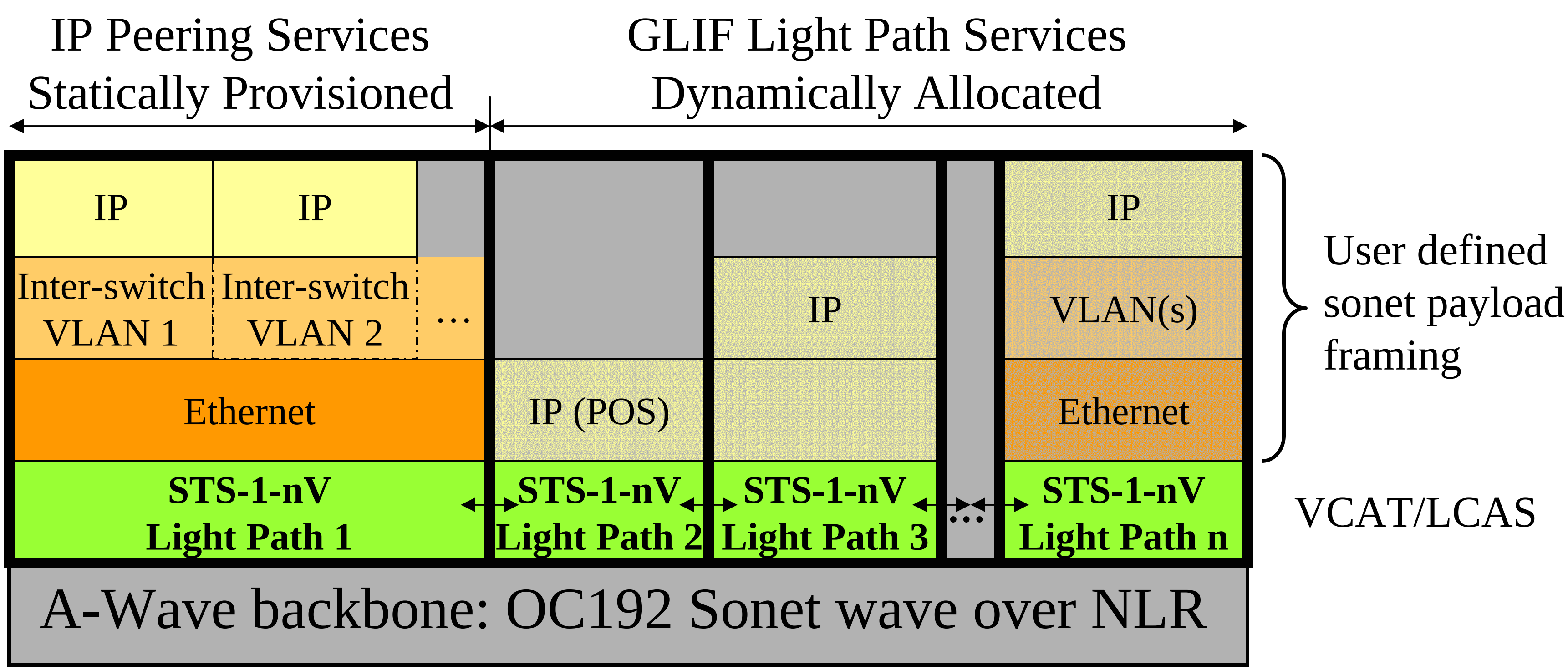
Generic A-Wave Node Architecture
(using separate switching fabrics)



Layer 3 Distributed Peering Ethernet Exchange Architecture

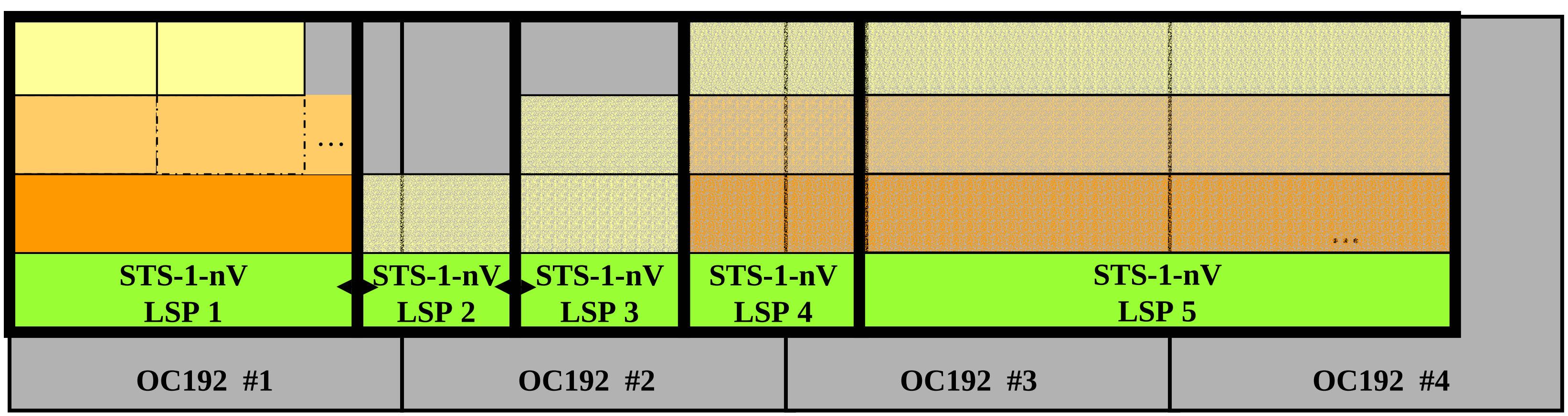


A-Wave Layered Services



A-Wave Backbone Expansion

- Light Paths can be statically provisioned or dynamically allocated as necessary using Virtual Concatenation (VCAT) features of sonet switches.
- Ethernet framed LPs will be mapped into sonet Virtual Container Groups (VCGs) using frame based Generic Framing Protocol (GFP-F)
- VCAT/LCAS allow light paths to be mapped across multiple backbone sonet circuits/links, providing transparent addition of capacity, efficient utilization of capacity, and dynamic grooming.
- Over time, as static capacity requirements change, or as additional sonet capacity becomes available, A-Wave can modify the capacity associated with each light path using the Link Capacity Adjustment Scheme (LCAS)



Regional Fan Out Considerations

- **How will participant networks take advantage of these services at the exhange points?**
  - **IP Peering is well understood and service/cost models exist**
  - **However, GLIF services may be a new issue for the RONs:**
    - In order to source or sink a deterministic GLIF light path, the RONs will need to engineer *dedicated* network resources into their regional service model and/or offerings –
    - Sonet to the edge is probably not necessary *IF* dedicated network resources at another layer are allocated. E.g. untagged ethernet over {wavelength, fiber}
    - Potentially *dynamic* allocation of GLIF services will be required in the RONs [to complement such in the core.] TBD…
    - These should not pose major cost or technical challenges as most existing DWDM gear already provides these capabilities
- **How will these services be cost-recovered?**
  - **Particularly dynamic GLIF light paths pose new isseus for business models**
  - **A-Wave needs to consider this issue as wel as the RONs.**

Regional Fan Out Considerations

- **How will regional networks extend these services out to the end users?**
  - **For GLIF services, the deterministic and predictable performance of the long haul sonet systems can be retained as long as the regional network avoids shared/best effort/asynchronous switching and forwarding elements.**
  - **I.e. A RON could extend ethernet over sonet service from the A-Wave sonet switch interface to the user via**
    - Standard sonet circuits across the RON to the user whereby the user un-encaps the GFP framed ethernet
    - WDM waves framed as sonet – see above
    - Basic ether“segment” over fiber – point to point ethernet from A-Wave client port to end user
    - WDM waves framed as ethernet – point-to-point wave, no ethernet switching along the regional path, or only very carefully managed switch utilizing advanced traffic shaping/policing capabilities.
  - **Conventional best effort Ethernet networks have the potential to replicate the layer3 unpredictability at layer2, and should be avoided.**
    - The degree that such jitter, latency, buffering constraints, etc will cause problems is still an open question in need or more study

Deployment Plans & Timeline

- **Phase 1: Deploy Ethernet Peering services**
  - **Business model, governance plan, and Phase 1 engineering**
    - Plans completed, orders in for gear and waves **July 1, 05**
  - **Installation and testing begins** **Sept 1, 05**
  - **Ethernet peering services launched** **Nov 1, 2005**
  - **Between JKV-ATL, ATL-WDC, WDC-NYC**
  - **10Gbs WAN PHY ethernet over NLR wave intially**
    - Software switchable to sonet if/when required
- **Phase 2: Sonet Engineering plan complete** **~CY06-Q1**
  - **Decision point: Sonet sub-layer insertion** **~CY06-Q2**
- **Phase 3: Deploy *dynamic* light path services** **~CY06-Q2+**
- **Phase 4: Expansion** **~CY07 ->**
  - **Integrate links between A-Wave, P-Wave, Northern Tier, etc**
  - **Expand core capacity with additional OC192 waves**

Atlantic Wave

- **For Further Information**
  - **Julio Ibarra**
  - **Don Riley**
  - **Jerry Sobieski**

  - **You know how to find these folks…☺**