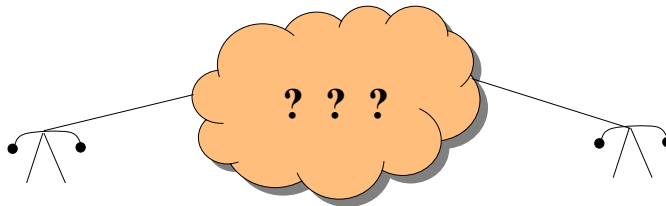


Network Planning Considerations and Techniques for Transport Networks

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What is Transport Network Planning?



- Vendor Perspective
- Carrier perspective
- OSS perspective

Transport Network Planning: Vendor Perspective

- Strategic Planning
 - Product Architecture Analysis
 - Analyze Network Impact on Product Features
 - Product Roadmap Evolution
 - Respond to Forward Looking RFIs
- Tactical Planning
 - RFP Response Generation
- Sales Enabling
 - Empower Non-technical Sales Force

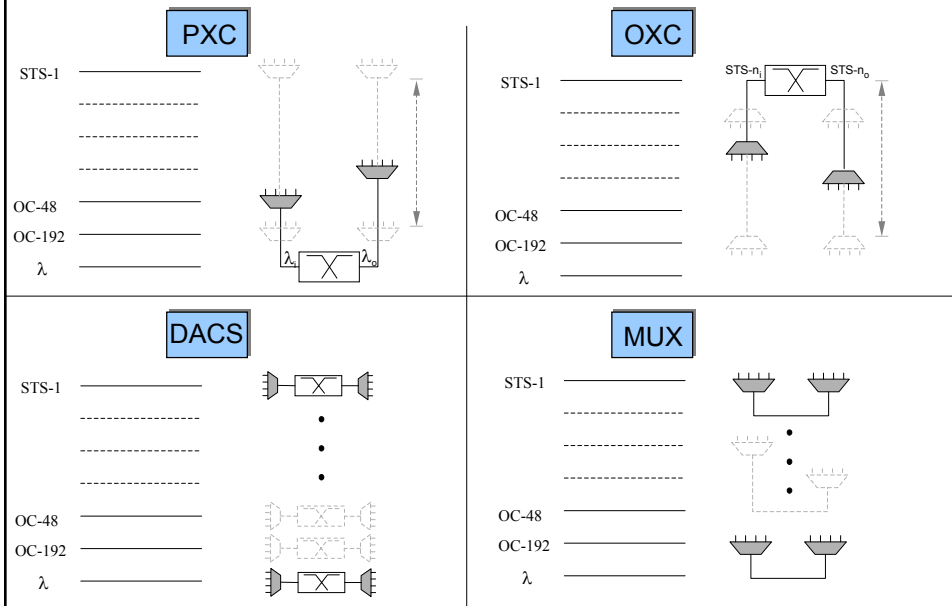
Vendor perspective: Strategic Planning

- What is Needed in the Planning Tool?
 - Flexibility to Model New Types of Equipment
 - Ability to Capture Different Office Architectures
 - Cost Sensitive Optimization
 - Scalability to handle Carrier Size Networks
 - Algorithm API for Custom Algorithms
 - Scripting/Macro interfaces to Allow Custom Preprocessing and Postprocessing of Data

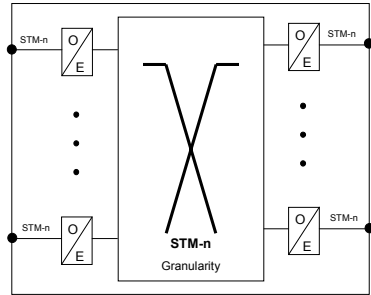
Vendor Perspective: Tactical Planning (RFP Responses)

- What is Needed in the Planning Tool?
 - Easy Capture of Customer Network Data
 - Carrier Class Scalability and Performance
 - Embedded Network Modeling
 - Multiyear Planning
 - Ability to Model a wide Range of Equipment including Legacy Equipment
 - Cost Sensitive Optimization
 - Balance Optimization Degree and Computational Complexity
 - Equipment Modeling Flexibility to Showcase Vendors' Product Offering

Vendor Perspective: Equipment Modeling

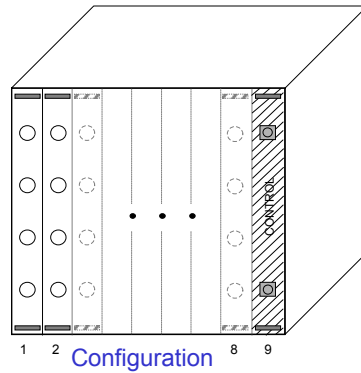


DACS/OXC model: Single-Level cross connecting



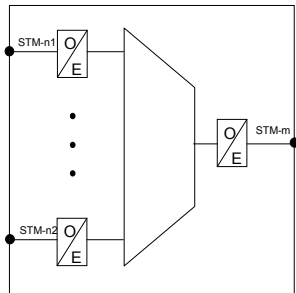
Functional Block Diagram

- Need to Model:
- OEO ports @ any rate
 - Switch fabric @ port rates



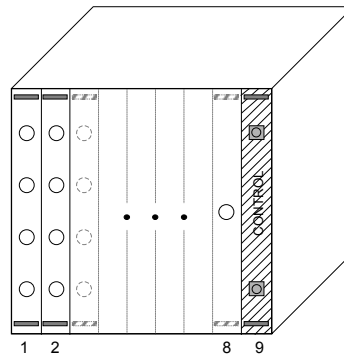
Configuration

MUX model: Multiple tributary rates multiplexing



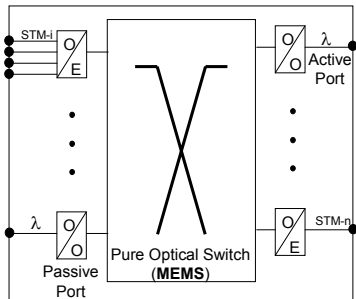
Functional Block Diagram

- Need to Model:
- OEO tributary ports @ any rate
 - OEO line ports @ any rate
 - Any mix and match of trib ports



Configuration

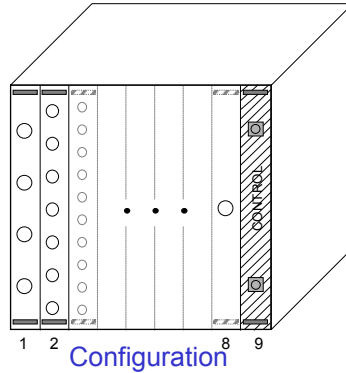
Photonic XC model: λ -level cross connecting,
No sub-rate grooming



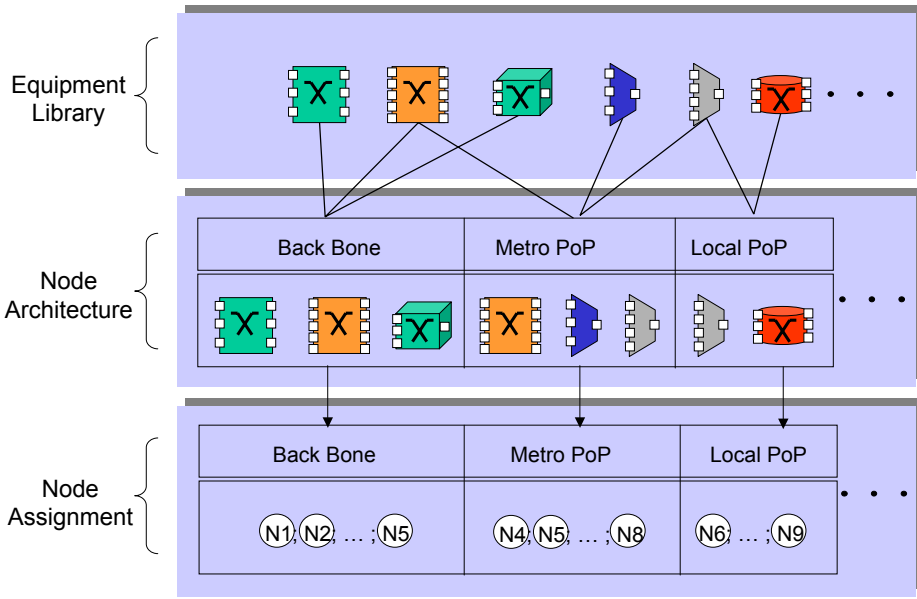
Functional Block Diagram

Need to Model:

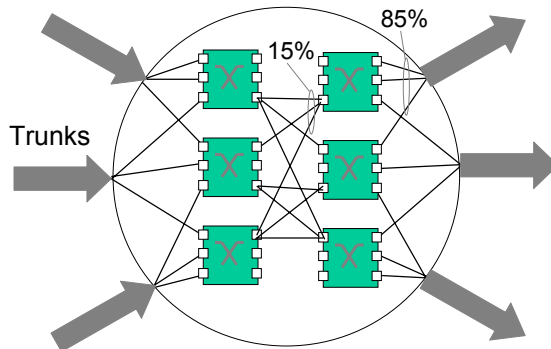
- Passive optical ports
- Active optical ports
- OEO long reach ports
- OEO short reach ports
- Muxing ports
- Any mix and match of ports



Equipment Library and Node Architecture

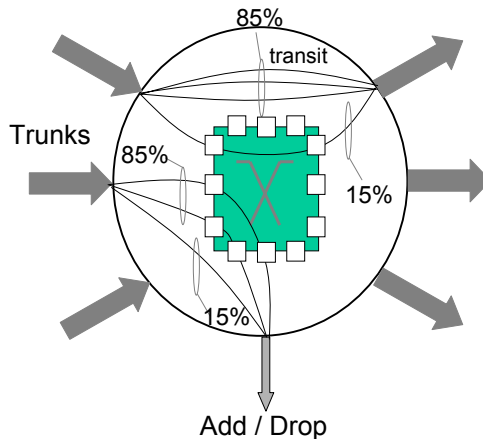


Intra-Node Connectivity between multiple pieces of Equipment



Flexible Connectivity inside a Node

Network Flexibility: Transit traffic vs. Add/drop traffic percentages

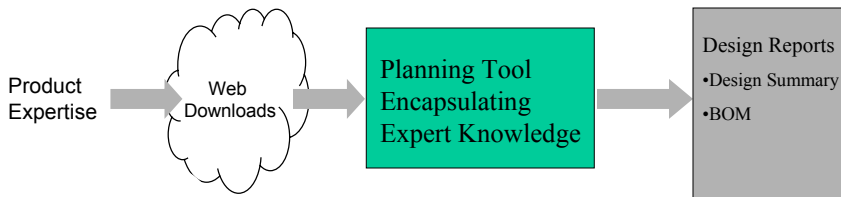


Flexible Connectivity inside a Node

Vendor Perspective: Sales Enabling (Non-Expert Version)

- What is Needed in the Planning Tool?

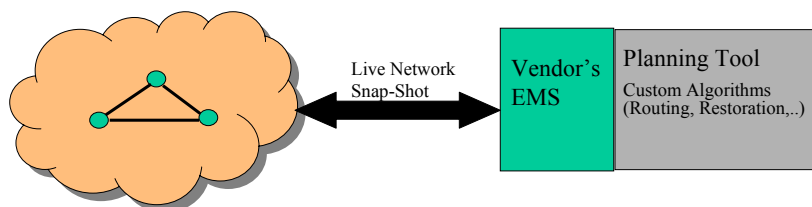
- Simple Fully Automated Sales Tool



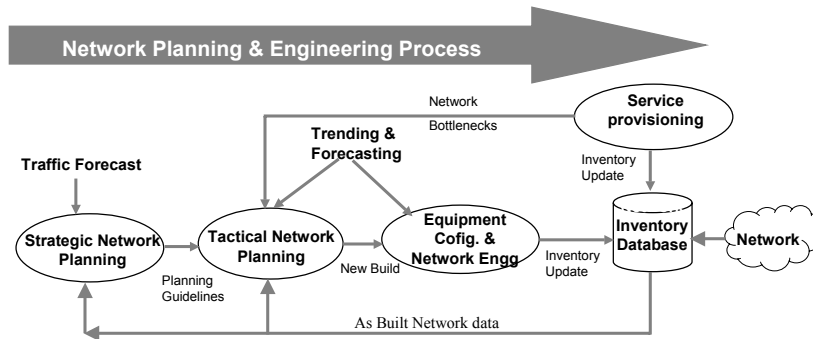
- Single Tool Solution
- Ease of Use
- Network Design Wizard
- Flexibility to Capture New Products and Changes
- Product Configuration and Permutations
- Optical Link Engineering
- Optimized Solutions

Vendor Perspective: Sales Enabling (Expert Version)

- What is Needed in the Planning Tool?
 - Show Case Vendor Product Offering in a Live Network
 - Emulate Product Capabilities to Show how Product Would Perform in Network



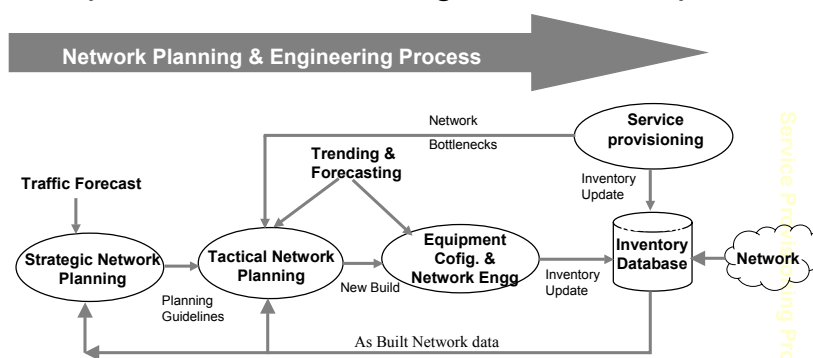
Transport Network Planning: Carrier Perspective



•Strategic Planning

- Technology/Architecture Analysis
- Long term Network Evolution Studies
- Vendor Benchmarking
- Develop Planning Guidelines

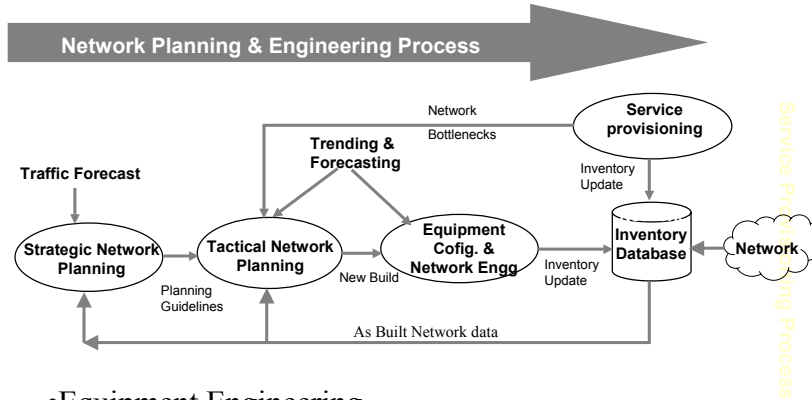
Transport Network Planning: Carrier Perspective



•Tactical Planning

- Identify and Resolve Potential Bottlenecks
- Resolve Network Bottlenecks Found in the Field
- Generate Optimized New-Builds

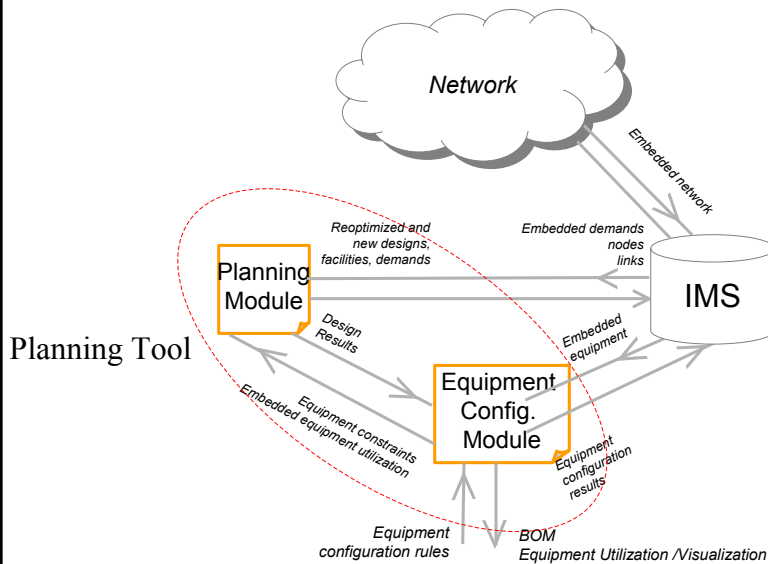
Transport Network Planning: Carrier Perspective



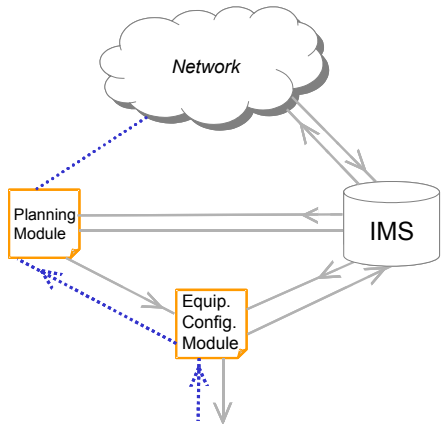
•Equipment Engineering

- Perform Detailed Equipment Configuration
- Generate BOM
- Interact with Purchasing/Project Management
- Provide Installation Guidelines to Deployment

Transport Network: Carrier Perspective - Data Flows



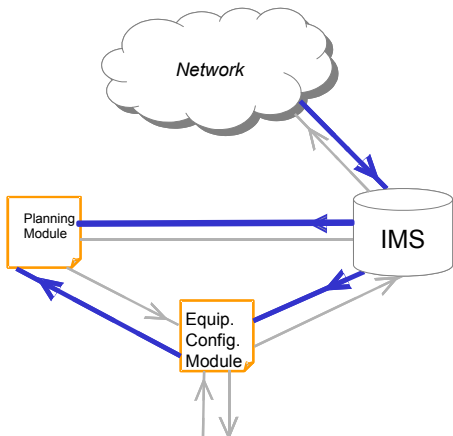
Carrier Perspective: Strategic Planning



- Evaluate new equipment capabilities
- Vendor benchmarking to support RFI/RFP process

Carrier Perspective: Tactical Planning

Network re-optimization



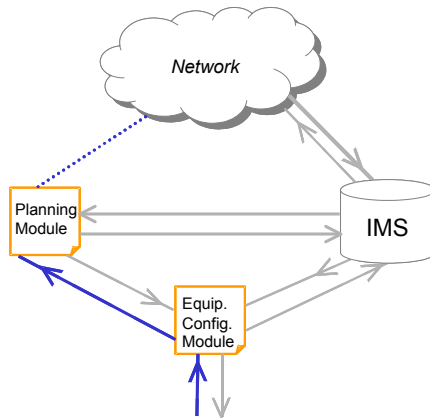
Network re-optimization requirements

Ensure re-optimized network can be provisioned by:

- Taking existing equipment capabilities into account
- Honoring existing equipment capacity constraints

Carrier Perspective: Tactical Planning

New build Optimization



Enable capture of new equipment configuration rules

Minimize total network cost

Ensure new network can be provisioned by:

- Ensuring new network design is consistent with new equipment capabilities
- Honoring existing equipment capacity constraints

Generate BOM and equipment utilization reports

Carrier Perspective: Equipment Engineering

What is Needed in the Equipment Configuration Module?

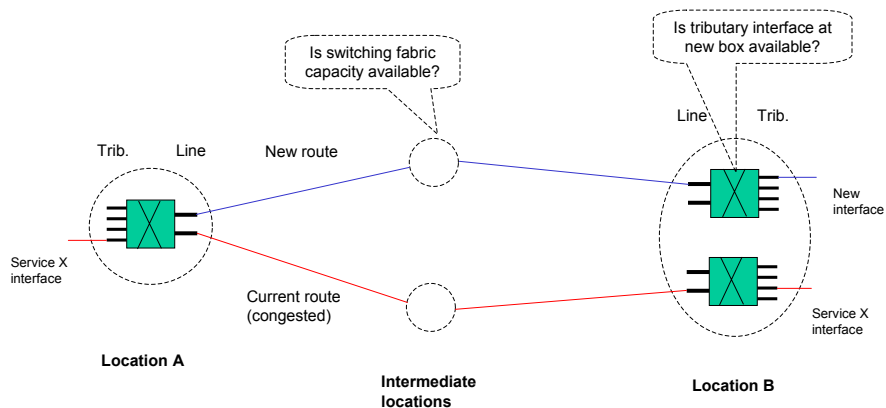
- Must Automatically and Optimally Configure Equipment
 - Traffic driven and rule based
 - Rules are defined in vendor specific equipment libraries
 - SONET/SDH, DWDM, PDH; Mux, DACS, ADM, Integrated XC
- Configuration Results Must include
 - Equipment composition: Bays, shelves, cards, sticks and ports
 - Bill Of Material (BOM)
 - Precise costing
- Greenfield as well as Embedded Network Configuration
 - Model Legacy as well as New Equipment

Carrier Perspective: General Considerations

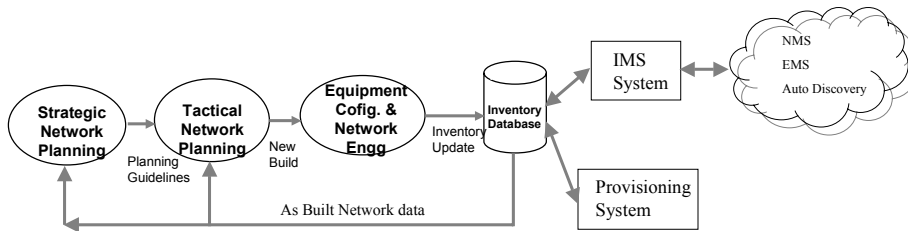
- Scalability
 - Network Partitioning with Split and Merge Capability
- Performance
 - Support Many Simultaneous Users
 - Thin-Client/Thick-Client Architectures
- Detailed Capture of As-Built Network
- Detailed Physical/Logical Equipment Model
 - Equipment Constrained Reoptimization
 - Equipment Constrained New-Build Optimization
 - Generate Orderable BOM for New Builds
- Process Automation Capability
 - Streamline Network Planning and Engineering Process

As-Built Network Reoptimization Example

Load Balancing/Route Optimization



Transport Network Planning: OSS Perspective



•Issues

- OSS Integration
- Keeping DB Synchronized
- Delivering As-Built Network Info to Planning Application
- Delivering As-Planned Network Info to IMS System
- Delivering Routing Guidelines to Provisioning Systems
- Process Automation?

Transport Network Planning: Techniques

Two Important Questions:

- How Does a Planning Tool Meet the Diverse Planning and Engineering Needs?
 - Get Away from the Tyranny of the Mathematician
 - Build Data models to facilitate Equipment Constrained Network Design
 - Build Optimization Algorithms Flexible Enough to Capture Equipment and "Business Rule" Constraints
 - Plan for Sophisticated DB Support to Achieve Scalability Via Split and Merge
- Can a Single Tool Do it All?
 - In Principle Yes, But Better to Have a Carrier Version and a Vendor Version

Transport Network Planning: Techniques

- Are All the Classical OR Algorithms Useless?
 - NO! But Use with Caution
 - Standard LP/IP Techniques Do Not Scale and Do Not provide Modeling Flexibility to Introduce New Constraints (New Equipment or New Business Rules)
 - Two Key Challenges
 - Designing a Comprehensive Data Model
 - Designing a set of Heuristic Algorithms that Balance Computational Complexity with Optimization Accuracy

Transport Network Planning: What are the Benefits?

- To Vendors
 - ~20% Improvement in Design Cost
 - => Better Margins, Better Hit Rate
 - Cut RFP Response Time in Half
 - => OpEx Savings
 - Streamlined RFP Process
 - => High Quality RFP Response, OpEx Savings
 - Sales Enabler (for Non-Carrier Sales)
 - => High Quality Designs at Low Cost Without Expert Involvement, OpEx Savings
 - Network Focused Product Enhancements

Transport Network Planning: What are the Benefits?

- To Carriers
 - ~20% Improvement in As-Built Network Optimization
 - => CapEx Deferral (> \$25M/Year for Typical Tier 1 Operators)
 - ~15% - 30% Improvement in New Build Optimization
 - => CapEx Savings (> \$50M/Year for Typical Tier 1 Operators)
 - Process Automation by Integrating Planning and Engineering
 - => OpEx Savings
 - Improved provisioning which takes Detailed Equipment Configuration Rules and Operator Business Rules into Account
 - => CapEx/OpEx Savings
 - Service Pricing Optimization Improves Competitive Position