

Global Concurrent Optimization (GCO) in PCE-based Network

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Outline

- GCO Definition
- Motivation
- Applications
- PCE-based Architecture
- Examples
 - Concurrent Path Computation
 - Non-disruptive Bulk Re-optimization
- Requirements and Extensions to PCEP
- Summary

GCO Definition

Global Concurrent Optimization (GCO) is a concurrent path computation application where **a set of TE paths** are computed concurrently in order to efficiently utilize network resources. A GCO path computation is able to **simultaneously** consider the **entire** topology of the network and the **complete** set of existing LSPs, and their respective constraints, and look to optimize or re-optimize the entire network to satisfy **all constraints** for all LSPs.

A GCO path computation can also provide an optimal way to migrate from an existing set of LSPs to a reoptimized set.

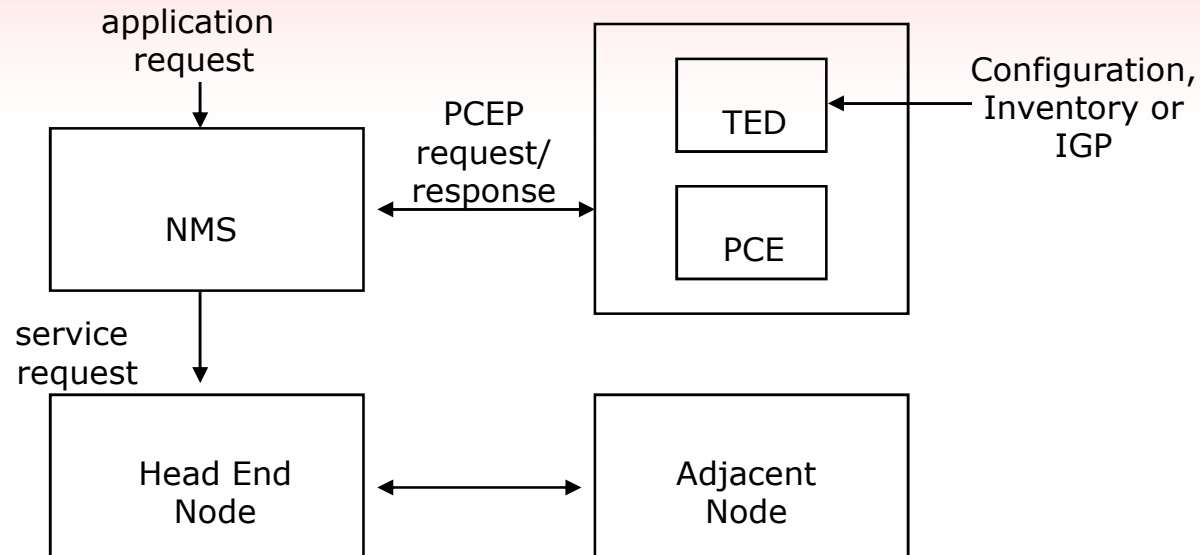
Motivation

- Global re/optimization is within the IETF PCE WG scope.
- Sequential path computation may result in sub-optimal use of network resources in some applications.
- Efficient utilization of network resources from a global network perspective would translate operations cost saving.
- GCO can facilitate minimization of disruption for bulk re-provisioning and its migration strategy

Application Scenarios

Greenfield Traffic Engineering For Packet/Optical Transport network	Re-Optimization of existing network For Packet/Optical network
<ul style="list-style-type: none">• Single-layer Traffic Engineering<ul style="list-style-type: none">– VNT/H-LSP– MPLS-TE, PTN, ETN, DWDM• Multi-layer Traffic Engineering<ul style="list-style-type: none">– SDH VC12/VC4, PTN over ODU– ETN/PTN over DWDM	<ul style="list-style-type: none">• Reconfiguration of existing network• Migration Strategy<ul style="list-style-type: none">– Make-before-break– Setup/Removal Order• Morphing Problem

PCE-based Architecture for GCO Application



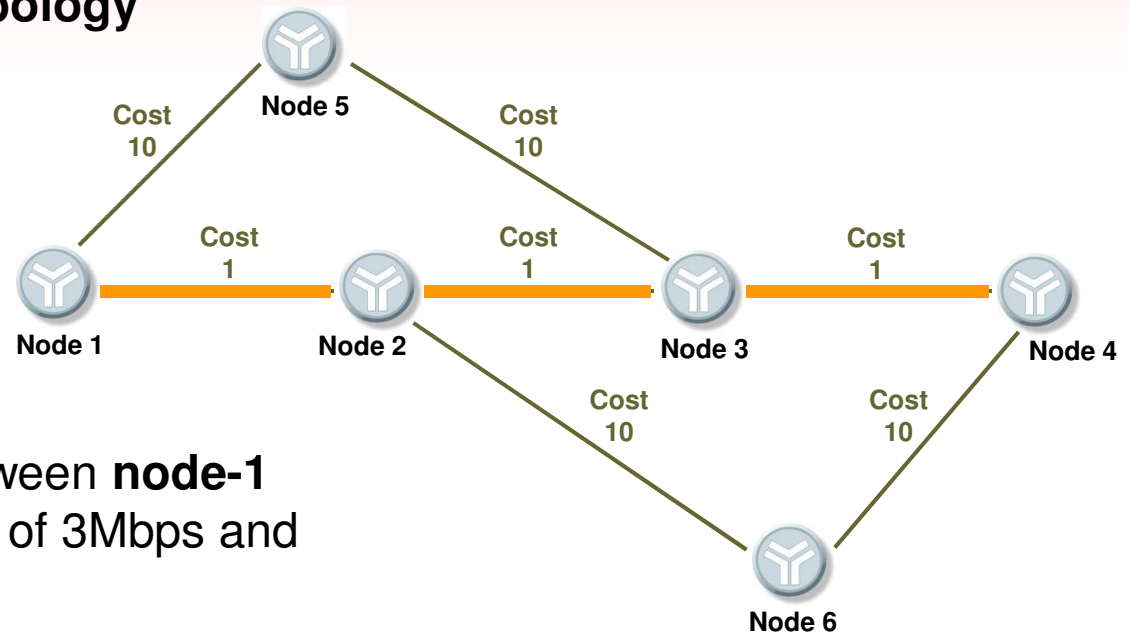
- PCE can be used as a tool for GCO application used by NMS
- May be a separate server or integrated into NMS
- TED fed by configuration, inventory or IGP




A sequential approach to path computation

Simple example – services requested from the same node

Consider a simple network topology

- All links are 5Mbps
- Various link costs

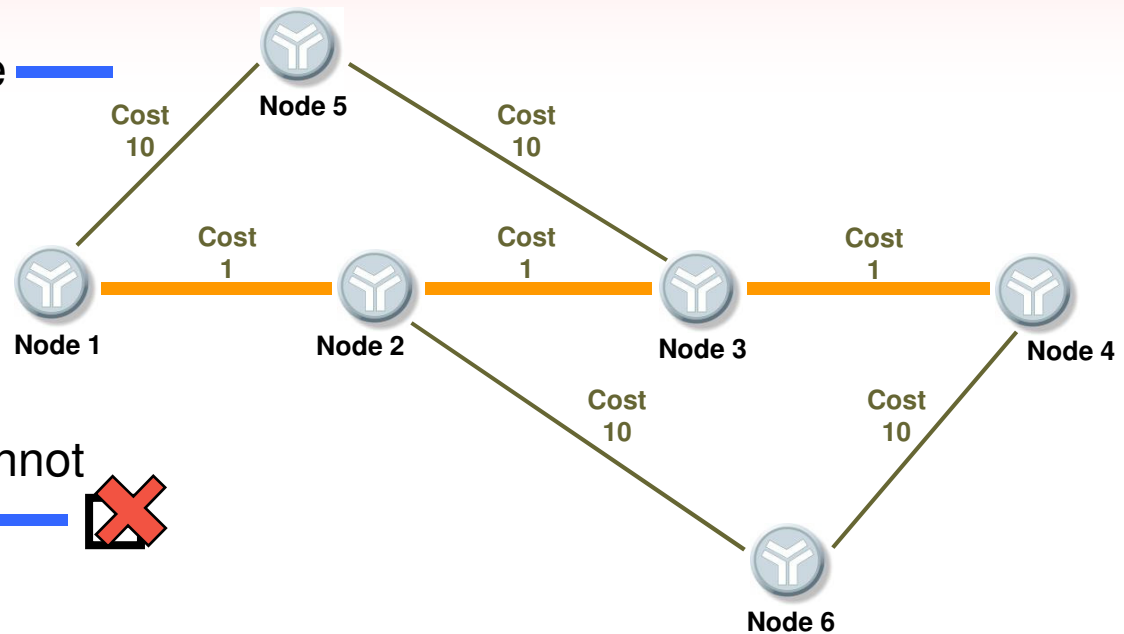



1. Request a service  between **node-1** and **node-4** with bandwidth of 3Mbps and minimal cost
2. Service is successfully placed along path 1-2-3-4  
3. Bandwidth utilisation on links with cost of 1 is now 60%

A sequential approach to path computation

Simple example – services requested from the same node

1. Then request a second service between **node-1** and **node-4** with bandwidth of 3Mbps and minimal cost



2. The second service request is unsuccessful - the network cannot satisfy the bandwidth needs — 

A concurrent approach to path computation

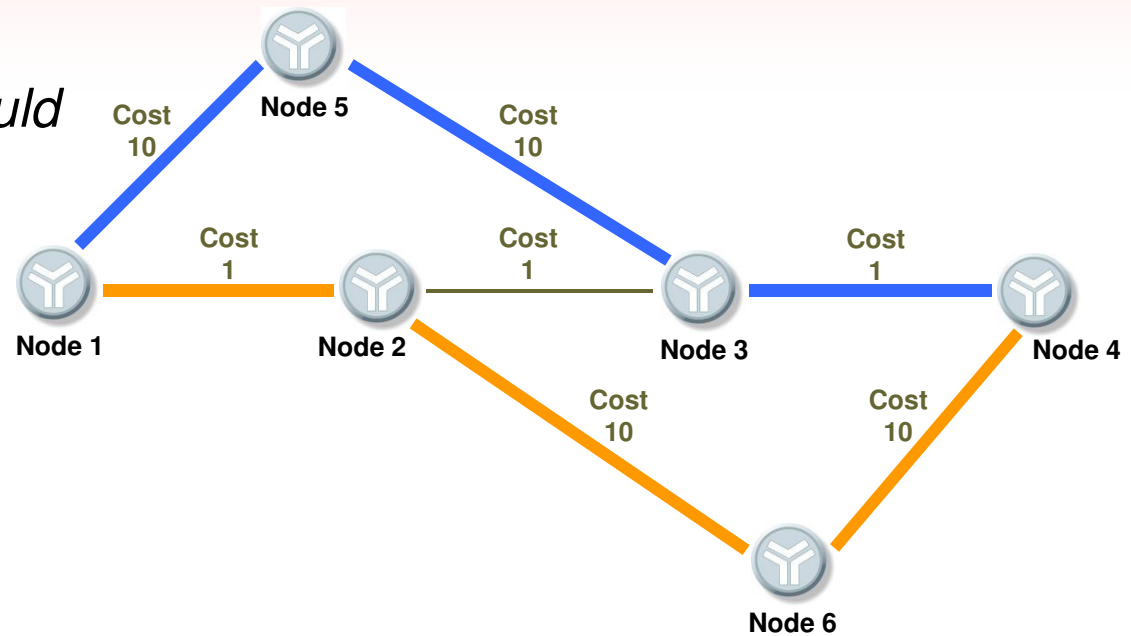
Simple example – services requested from the same node

A concurrent computation could satisfy all service constraints

Service 1 – 3Mbps



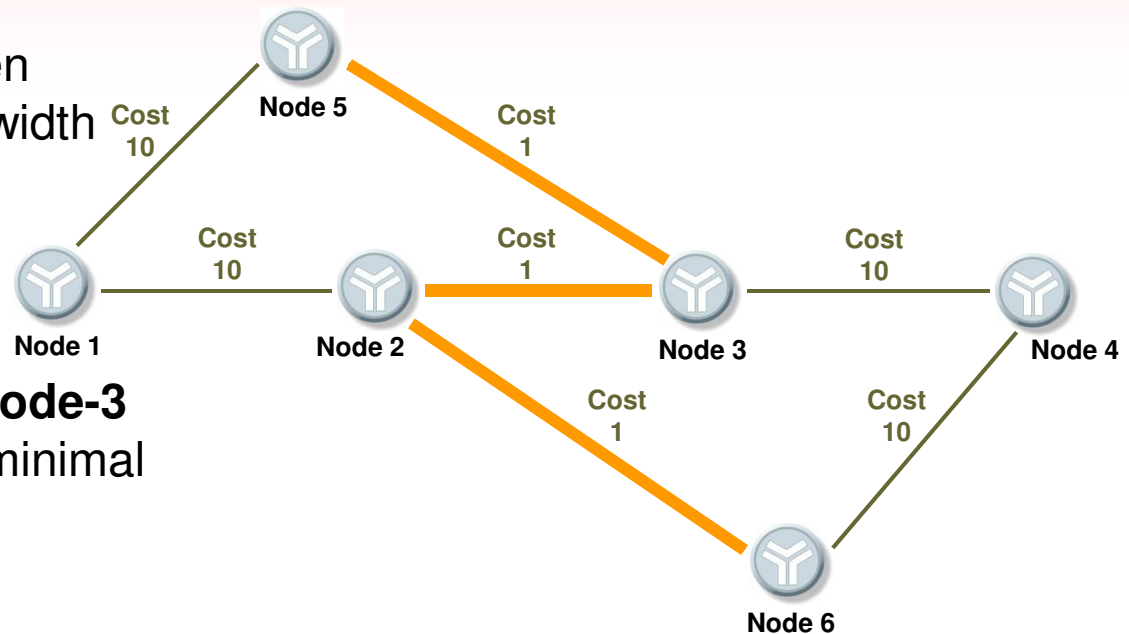
Service 2 – 3Mbps



A sequential approach to path computation

Simple example – services requested from different nodes

1. Request a service — between **node-5** and **node-6** with bandwidth of 3Mbps and minimal cost
2. Then request a second service between **node-1** and **node-3** with bandwidth of 3Mbps and minimal cost



Service 1 – 3Mbps —

Service 2 – 3Mbps —

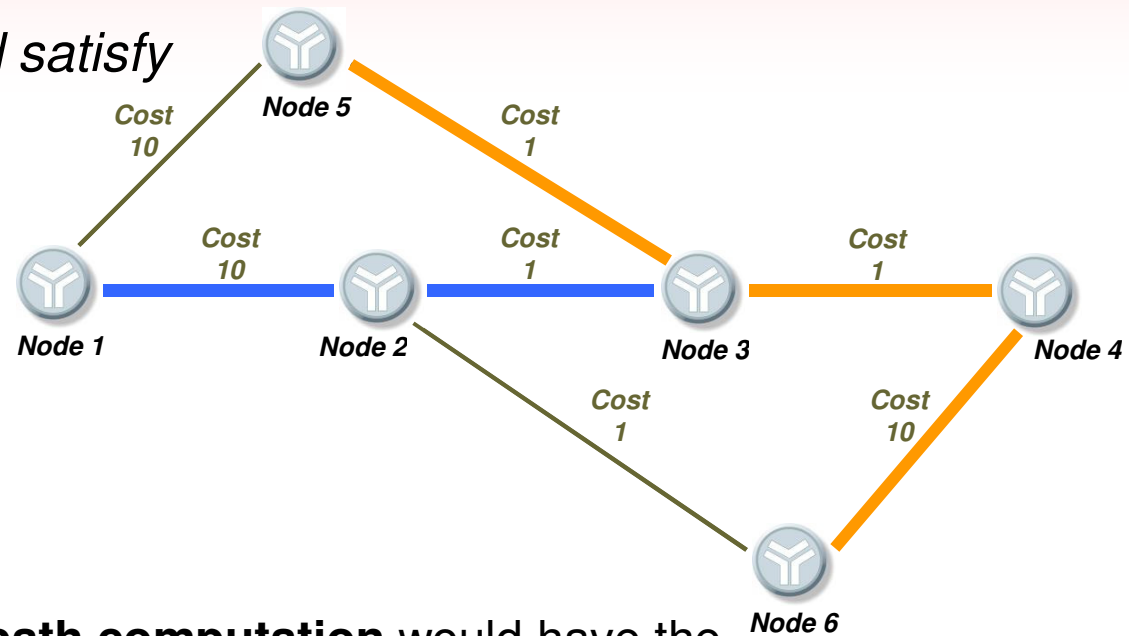
A concurrent approach to path computation

Simple example – services requested from different nodes

A concurrent operation would satisfy all service constraints

Service 1 – 3Mbps  

Service 2 – 3Mbps  

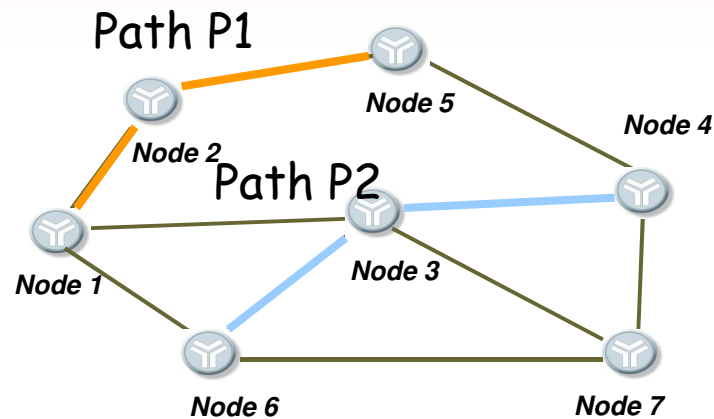


A PCE supporting **concurrent path computation** would have the ability to consider **global** network capacities and properties, all service requirements and constraints, and then optimally place all services to meet the service requirements within the confines of the network infrastructure.

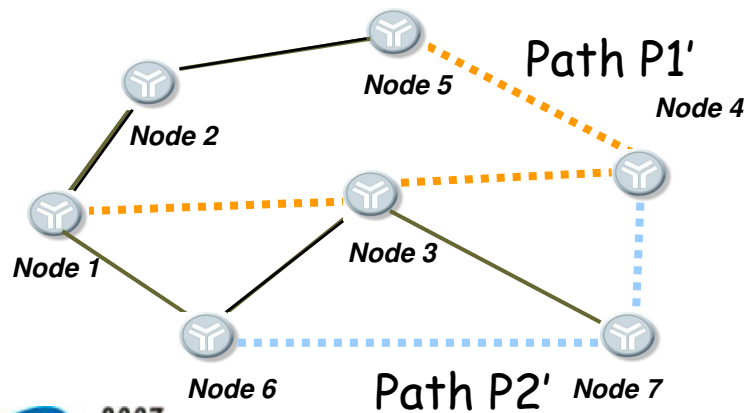
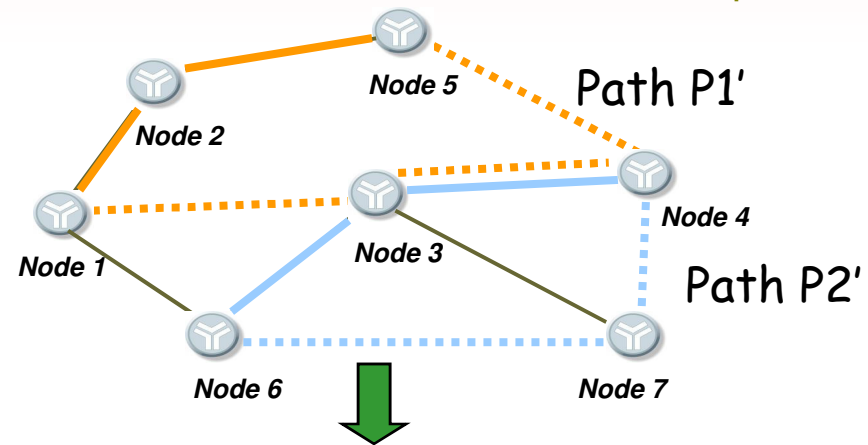
Non-Disruptive Bulk Re-optimization

via Make-Before-Break and Order

Consider a network with two established requests: R1: Path P1 and R2: Path P2



During Re-optimization, the PCE may provide:
R1: Path P1', Remove order 4, Setup order 2
R2: Path P2', Remove order 2, Setup Order 1



This indicates the NMS should do the following sequences of tasks:

1. Setup Path P2'
2. Remove Path P2
3. Setup Path P1'
4. Remove Path P1'

Key PCECP Requirements

- Global Objective Function (GOF)
 - Minimize the sum of all TE LSP costs (min cost)
 - Maximize the residual bandwidth on the most loaded link
 - Evenly allocate the network load to achieve the most uniform link utilization across all links
- Global Constraints (GC) field
 - Max Link Util, Min Link Util, Max Hop, Exclusion of links/nodes, Overbooking Factor
- Global Concurrent Vector (GCV)
- Multi-Session (MS)
 - Indicator, session sequence number, final session indicator
- Disruption Minimization Mechanism in Bulk Re-optimization/Migration
 - The Request for the Order
 - Setup order and Removal order In Response
 - Inclusion of the set of previously computed paths to avoid double bandwidth accounting
 - Make-before-Break indicator

PCEP Protocol Extensions

(reference: draft-lee-pce-global-concurrent-optimization)

- **GCO Indicator** – a new flag (C flag) in the SVEC object
- **GOF** (Global Objective Function) - three code points requested in the PCE OF Registry
- **Request for the order** of LSP to minimize disruption in case of bulk provisioning – a new flag (D flag) in the RP object
- **Make-before-break Indicator** – a new flag (M bit) in the RP object
- **The Order Response** TLV defined in the RP object in the PCRep Message: Setup Order and Delete Order
- **Global Constraints** (GC) Object defined: MU, mU, OB, MH, XRO
- **Multi-Session** (MS) Object is defined: F bit, M-Session ID, Sequence Number
- Two new flags added to NO-PATH-VECTOR TLV in the NO-PATH object: 0x03: no migration path found; 0x04: no feasible solution found
- **New Error-Type** (14) and two new Error-values are defined to indicate errors associated with GCO: memory overflow, GCO not capable
- A new Error-Value (3) is defined in the existing Error-Type (5) to indicate “GCO not allowed under policy.”

GCO Summary

- Architecture/Protocol
 - NMS-based PCE solution
 - Support IETF PCEP extension
- Applications
 - Extends the PCE intelligence to address the need for computing a set of TE LSPs concurrently
 - Greenfield TE for optical transport networks
 - Migration & Re-optimization
- Benefits
 - Efficient network resource utilization that would translate OPEX savings
 - Solutions to carrier's network planning/provisioning needs

Thank You!