Specification Sheet: Logic for Regenerator and OPC Placement in Python Tool

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Logic Summary: Python tool for Regenerator and OPC Placement

This document outlines the logic to be implemented in the Python tool for determining regenerator and Optical Phase Conjugator (OPC) placement in optical networks, and for calculating the residual uncompensated dispersion distance.

1 Regenerator Placement Logic

1. **Reach Threshold:** Utilize a fixed regenerator reach threshold of **1500 kilometers**. This threshold is a globally defined parameter.
2. **Source/Destination Exclusion (Including Connected ROADMs):** Regenerators are **never** placed at the true source node or the true destination node of a path. **This exclusion also explicitly includes the ROADMs that are directly connected to the source and destination nodes (often characterized by very short link distances like 0.01 miles). Regenerator placement is restricted to intermediate ROADM nodes only.**
3. **Iterative Distance Check:** For each path, track the cumulative distance from the source node.
4. **Regenerator Trigger Condition:** If the cumulative distance since the last regenerator (or from the source) exceeds **1500 kilometers**, a regenerator is required.
5. **Regenerator Location:** Place the regenerator at the **ROADM node immediately preceding** the link that caused the 1500 km threshold to be exceeded.
6. **Unreachable Direct Links:** If a direct link (source to destination, no intermediate ROADMs) is longer than 1500 kilometers, consider the path **unreachable**. No regenerator is placed.
7. **No Regenerators Needed (Short Paths):** If the total path distance is less than or equal to 1500 kilometers, no regenerators are placed.

2 OPC Placement Logic

- **General Principle:** OPCs are always placed at ROADM node locations, excluding source and destination nodes. **This exclusion also applies to the ROADMs directly connected to the source and destination nodes.**
- **Case 1: No Regenerators on Path**
  - **Condition:** If a path requires **no regenerators** (total path distance $\leq$ 1500 km) AND has **three or more ROADM nodes (including the Source and Destination ROADMs)**.
  - **Action:** Place **one OPC** at the ROADM node closest to the geographical midpoint of the **entire path** (excluding true source and destination nodes, but **including Source and Destination ROADMs** when counting ROADM nodes and determining the midpoint).
- **Case 2: Regenerators Placed on Path (Section-Based OPC Placement)**
  - **Path Sections:** Divide the path into sections defined by consecutive regenerators, or source-regenerator, or regenerator-destination.
  - **OPC per Section Condition:** For each section:
    - **Condition:** If the section has **three or more ROADM nodes**.

    - * **Action:** Place **one OPC** at the ROADM node within that section closest to the **midpoint of that section**.
  - **No OPC for Short Sections:** If a section has fewer than three ROADM nodes, do **not** place an OPC in that section.
  - **Maximum OPCs per Section:** At most, one OPC is placed per section.
- **OPC Location Restriction:** OPCs are placed only at existing ROADM node locations, never at source or destination nodes. **This explicitly excludes placement at Source and Destination ROADMs as well.**

3 Residual Distance Calculation Logic

- **Scenario 1: No OPCs on Path**
  - **Condition:** If a path has **no OPCs** placed.
  - **Residual Distance Calculation:** The residual distance is the **distance of the last segment** (from the last regenerator to the destination node). If no regenerators are present, the residual distance is the **total distance of the entire path**.
- **Scenario 2: OPC(s) on Path**
  - **Condition:** If a path has one or more OPCs.
  - **Residual Distance Calculation:**
    1. For each OPC:
       - * Identify the path section containing the OPC.
       - * Calculate the distance of the **left segment** (section start to OPC location).
       - * Calculate the distance of the **right segment** (OPC location to section end).
       - * Calculate the **absolute difference** between the left and right segment distances. This is the residual distance for that OPC.
    2. **Total Residual Distance:** Sum the residual distances calculated for all OPCs on the path.