TVR (Time-Variant Routing) Applicability

draft-zdm-tvr-applicability

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Why This Document in TVR WG?

Specifically, the TVR WG will work on these items:

(1) Problem Statement and Use cases
…
(2) Requirements
…
(3) Information Model
…
(4) Data Model
..
(5) ***Applicability Statement***

This document should provide an applicability statement ***on how the information and data models may be used, along with required ancillary IETF technology, to solve the use cases and requirements***.

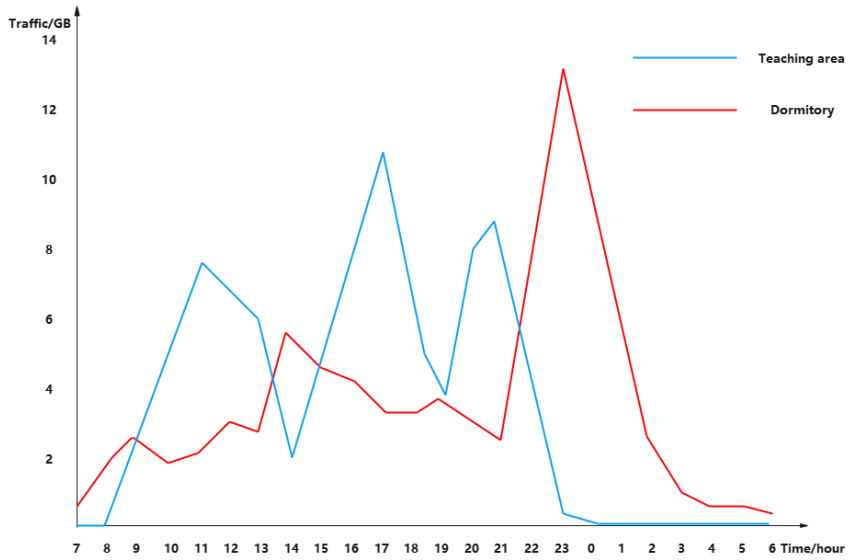
Excerpt from the TVR WG Charter

Main Document Contributions

- Identify and walk through using a ***concrete use case***
- Document the ***applicability of TVR YANG modules*** (and other related ones)
- Discussion ***time synchronization and protocol*** applicability
- Identify and discuss ***operational*** considerations

Use Case Examples

- Tidal Network Example
  - Traffic on the network has an obvious tidal period, including heavy-traffic periods and light-traffic periods
    - Network topology change caused by specific traffic pattern.
  - The time duration of heavy traffic and light traffic are clearly identifiable
    - Students or employees work specific hours
    - Network change will occur twice per day
  - The switching time between the heavy-traffic period and the light-traffic period is well established
    - Working time and day of week are predictable
- Is it sufficient to consider only tidal network use cases in Applicability I-D?

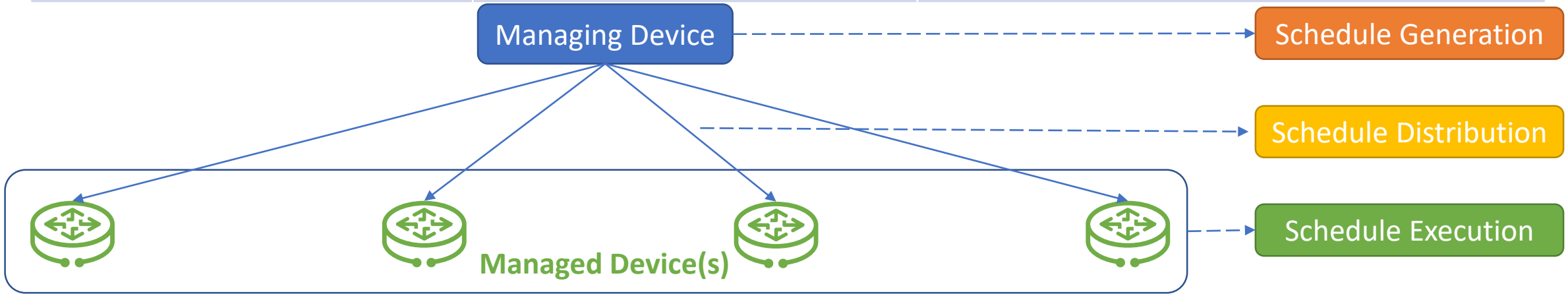


Tidal effect of traffic in campus network

Applicability of TVR YANG Model in Tidal Network(1/3)

- In which scenarios TVR data model is applicable?

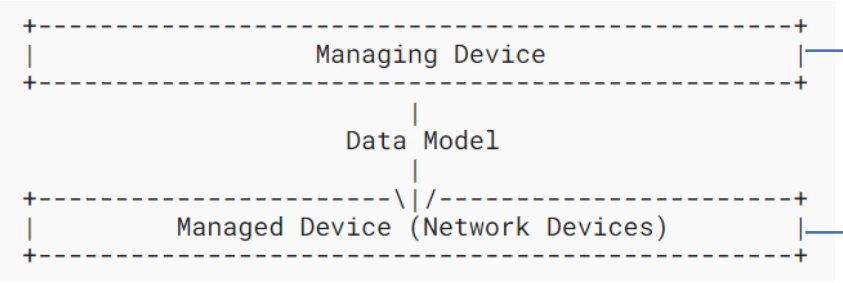
Schedule Generation Manner	Schedule Execution Manner	TVR YANG Applicable?
Centralized	Centralized	Yes(Generated and Executed at different devices)
Distributed	Distributed	No
Centralized	Distributed	Yes



Applicability of TVR YANG Model in Tidal Network(2/3)

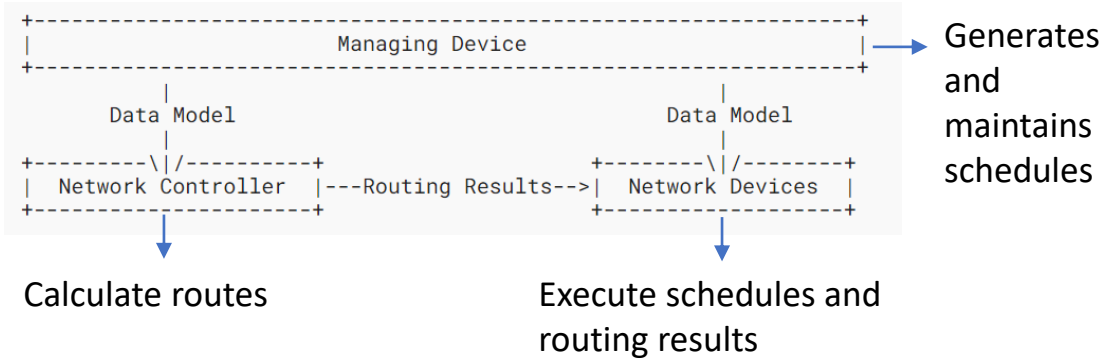
- Network model and interactions

Distributed Model



- Interactions
  - Managing devices deliver schedules to managed devices using the TVR YANG model

Centralized Model



- Interactions
  - Managing devices deliver node-specific schedules to network devices using the TVR Node YANG module
  - Managing devices deliver topology schedules to controller using the TVR Topology YANG module
  - Network controllers deliver routing decisions to network devices using dedicated YANG modules

Applicability of TVR YANG Model in Tidal Network(3/3)

- Encoding of TVR YANG Model

TVR data model defines the following YANG modules:

- “ietf-tvr-schedule” module contains the schedule YANG definitions;
- “ietf-tvr-topology” module defines a network topology with a time-variant availability schedule;
- “ietf-tvr-node” module is to be used to manage the scheduled attributes of a single node.

All of these modules are applicable in Tidal Network to manage devices and deliver topology information.

A JSON example to illustrate the use of “ietf-tvr-node” to shut down a wireless link from 19:00 to 7:00 every day.

```
{
   "ietf-tvr-node:node-schedule":[
      {
         "node-id":1234567890,
         "node-power-schedule":{
            "power-default":true,
         },
         "interface-schedule":[
            {
               "name":"Wlan0",
               "default-available":false,
               "attribute-schedule":{
                  "schedules":[
                     {
                        "schedule-id":111111,
                        "recurrence-first":{
                           "utc-start-time":"2025-12-01T19:00:00Z",
                           "duration":43200
                        },
                        "utc-until":"2026-12-01T00:00:00Z",
                        "frequency":"ietf-schedule:daily",
                        "interval":1,
                        "attr-value":{
                           "available":true
                        }
                     }
                  ]
               }
            }
         ]
      }
   ]
}
```

Management Protocols

- NETCONF
  - Provides a robust mechanism for managing ***complex network configurations***
  - Supports ***atomic transactions***, which ensures schedules involving multiple resources are applied fully, preventing partial updates that could lead to configuration inconsistencies. This is important for TVR environments.
  - Supports the ***validation of configurations prior to commitment***, allowing operators to verify the correctness of schedules before they are applied
- RESTCONF
  - Provides a ***simpler***, stateless method for interacting with network devices, suitable for use cases requiring lightweight, rapid configuration
  - Provides a streamlined approach to network configuration and management by ***RESTful interface*** over HTTP. It has advantages in scenarios where ***quick adjustments*** to schedules are needed or where integration with web-based or cloud-native systems is a priority
- Summary
  - NETCONF would be the preferred protocol for ***large-scale, critical scheduling operations requiring validation and rollback mechanisms***.
  - RESTCONF would be the preferred protocol for ***smaller-scale or isolated scheduling tasks***.
  - RESTCONF would be preferrable ***between service/network orchestrators***

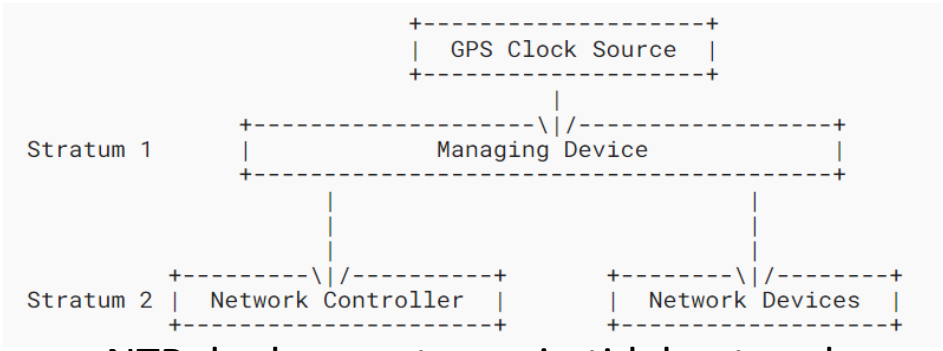
Time Synchronization

- Hardware-based protocols
  - ***Rely upon dedicated hardware*** to ensure clock synchronization, such as GPS and Precision Time Protocol (PTP)
  - ***Have higher precision and stability***, but also have higher cost due to the dedicated Hardware
  - Appropriate for networks with critical time synchronization requirement

- Software-based protocols
  - ***Synchronize clocks through software packages running on systems***, such as Network Time Protocol (NTP) and Simple Network Time Protocol (SNTP)
  - ***Simple and applicable to common hardware devices*** but have ***lower precision***
  - Appropriate for most of the TVR use cases

Time Synchronization in Tidal Network

- Time synchronization precision requirements of tidal network : ***Second level***
- NTP
  - Uses a hierarchical structure of time sources. Each level of this hierarchy is termed a stratum
  - Have ***higher precision:*** it can realize the synchronization at tens of milliseconds level.



NTP deployment case in tidal network

- SNTP
  - Simplifies the complex NTP synchronization function and is ***suitable for networks with limited resources and loose precision requirements***. The synchronization precision still can be guarded under seconds
  - Can be used as ***an alternative clock synchronization protocol for Tidal Network***

Schedule Database

- Data Structure

Based on TVR YANG modules, the schedule database should contain four types of schedule entries:

- ***Node power schedule*** entry
- ***Interface schedule*** entry
- ***Node schedule*** entry
- ***Links schedule*** entry

- Schedule Database Requirements
  - Schedule database should support “add”, “update”, and “delete” operations
  - When adding or updating a schedule entry, the execution node needs to check whether resource ***conflicts*** exist between the current schedule and existing schedules
  - Schedules are updated and deleted based on schedule IDs
    - Schedule IDs must be ***unique*** in a time-variant domain

Sample Operational Considerations

- ***Coordinated Network Events***
  - TVR often coordinates routing changes ***anticipating events*** like predictable link downtimes
- ***Accurate Scheduling of Paths***
  - 'TVR schedule'-capable nodes will ***dynamically adjust forwarding paths*** based on planned changes
- ***Time-Stamped Data Models***
  - TVR will require the use ***time-stamped data*** to make interface management decisions
- ***Schedule Execution Considerations***
  - A link coming up or a node joining a topology should not have any functional change until the change is ***proven to be fully operational***
  - A link or node is to be removed from the topology, then the network should ***act before the anticipated change*** to route traffic around the expected topological change.

Next Steps

- Suggestions for other use cases to assess the applicability are welcome
- Likewise, we welcome contributions to the operation and security considerations
- TVR use case demo hackathon
  - Based on the current use case in the I-D;
  - Looking for partners for the hackathon;
- Is the document a good start for the applicability item?
  - If so, we request to consider WG adoption