Transactive Control: An Approach for Widespread Coordination of Responsive Smart Grid Assets

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Overview

- Background on Pacific Northwest Smart Grid Demonstration Project
- Transactive Control Approach
- Transactive Control Nodes
- Implementation Challenges

Pacific Northwest Demonstration Project

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

What:

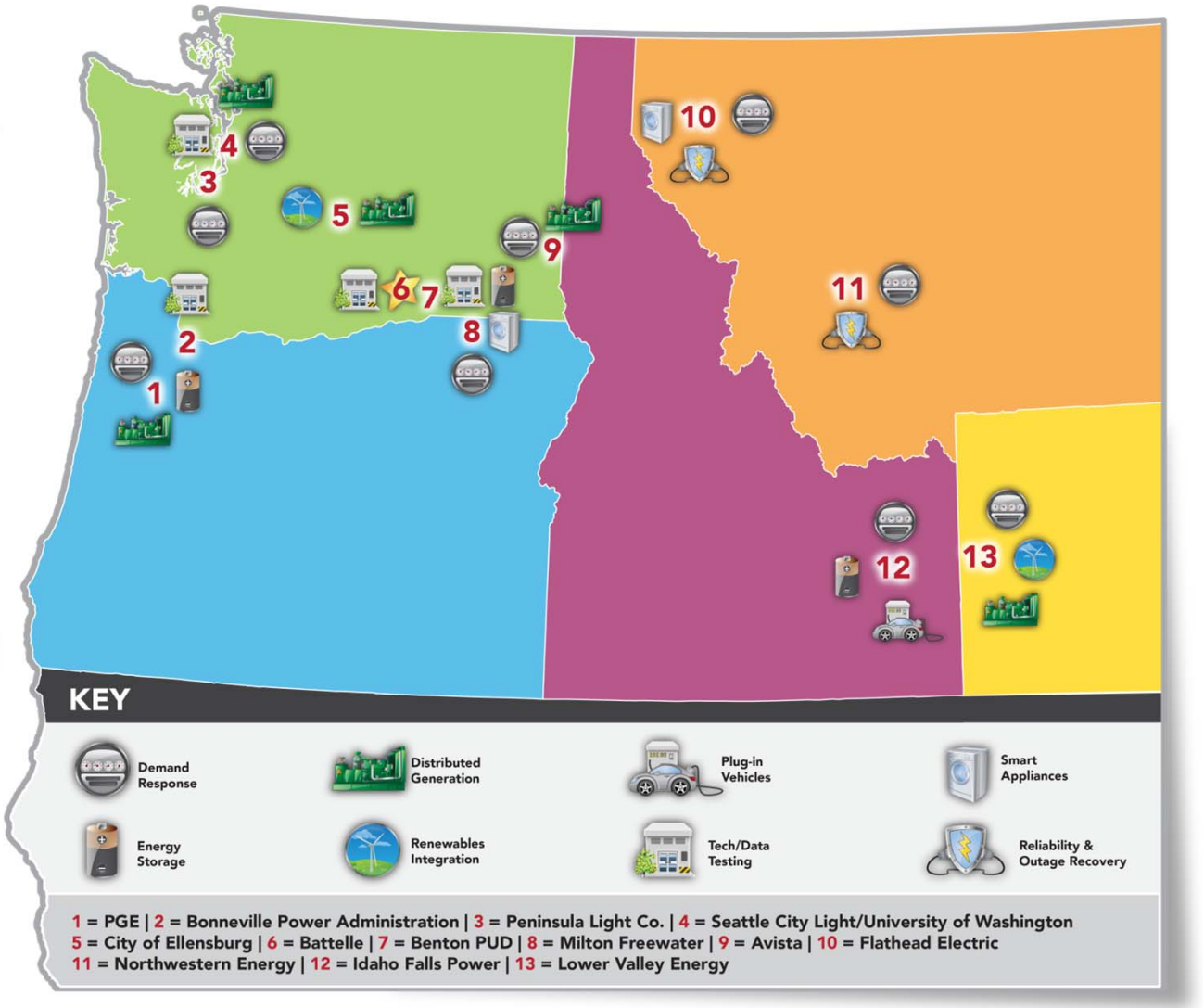
- $178M, ($89M private, $89M ARRA-funded), 5-year demonstration
- 60,000 metered customers in 5 states

Why:

- Quantify costs and benefits
- Develop communications protocol
- Develop standards
- Facilitate integration of wind and other renewables

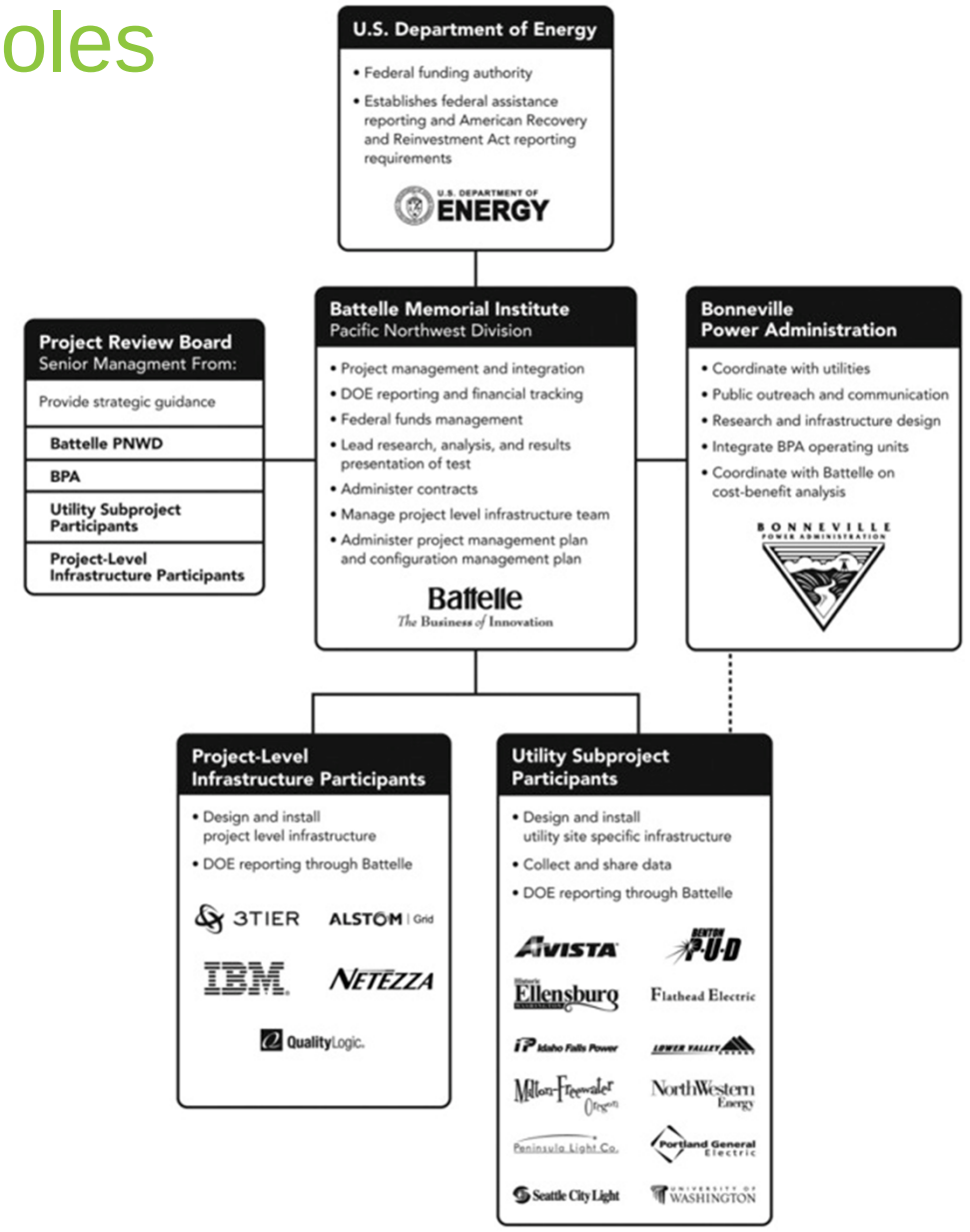
Who:

Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors



Project Structure / Roles

- Battelle Memorial Institute, Pacific Northwest Division
- Bonneville Power Administration
- 11 utilities (and UW) and their vendors
- 5 technology infrastructure partners

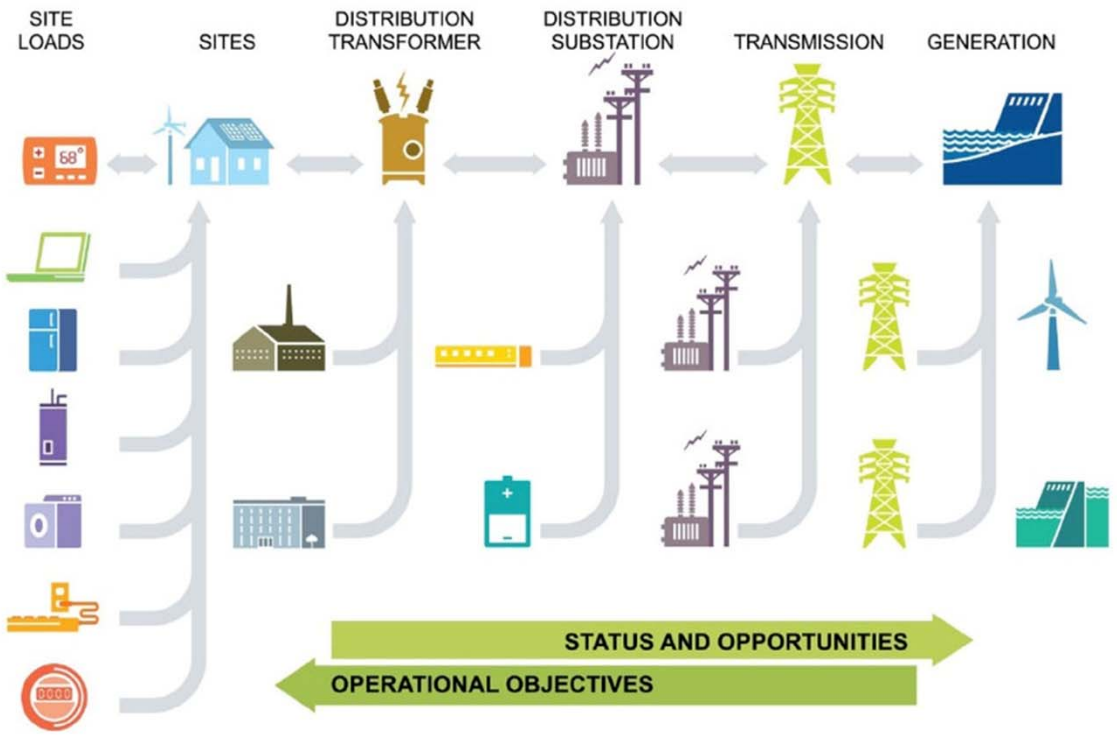


Project Basics

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

Operational objectives

- Manage peak demand
- Facilitate renewable resources
- Address constrained resources
- Improve system reliability and efficiency
- Select economical resources (optimize the system)



Aggregation of Power and Signals Occurs Through a Hierarchy of Interfaces

Some Definitions

- Transactive Control

  A single, integrated, smart grid incentive signaling approach utilizing an economic signal as the primary basis for communicating the desire to change the operational state of responsive assets.

- Transactive node

  A physical point within an electrical connectivity map of the system. Electrical energy flows through a transactive node.

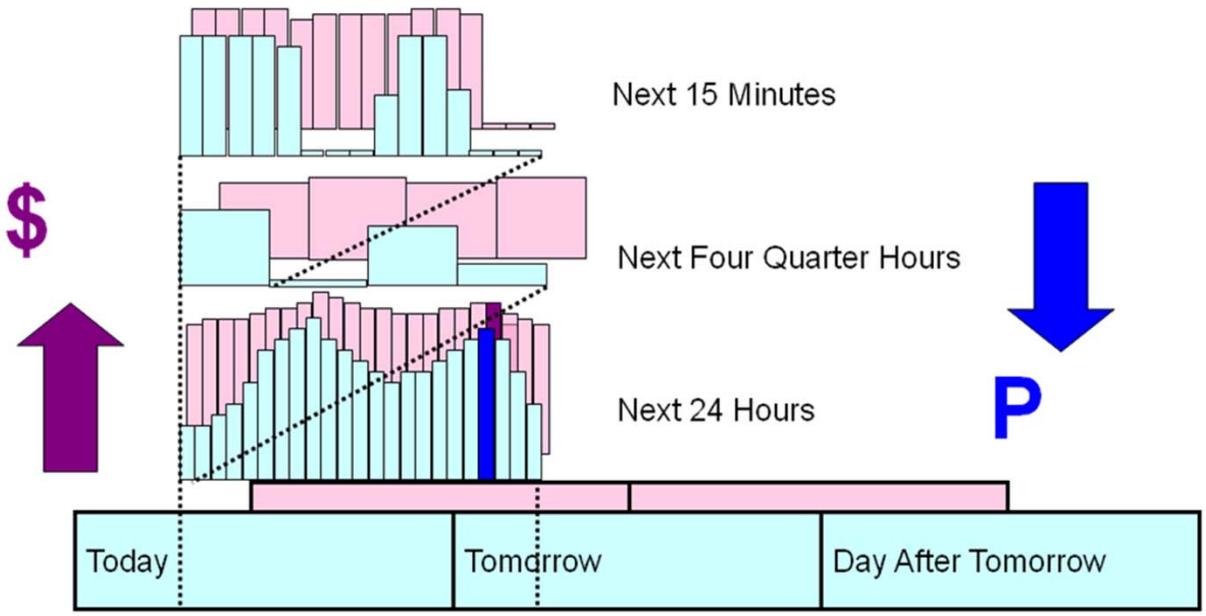
- Transactive Incentive Signal (TIS)

  A representation of the actual delivered cost of electric energy at a specific system location (e.g., at a transactive node). Includes both the current value and a forecast of future values.

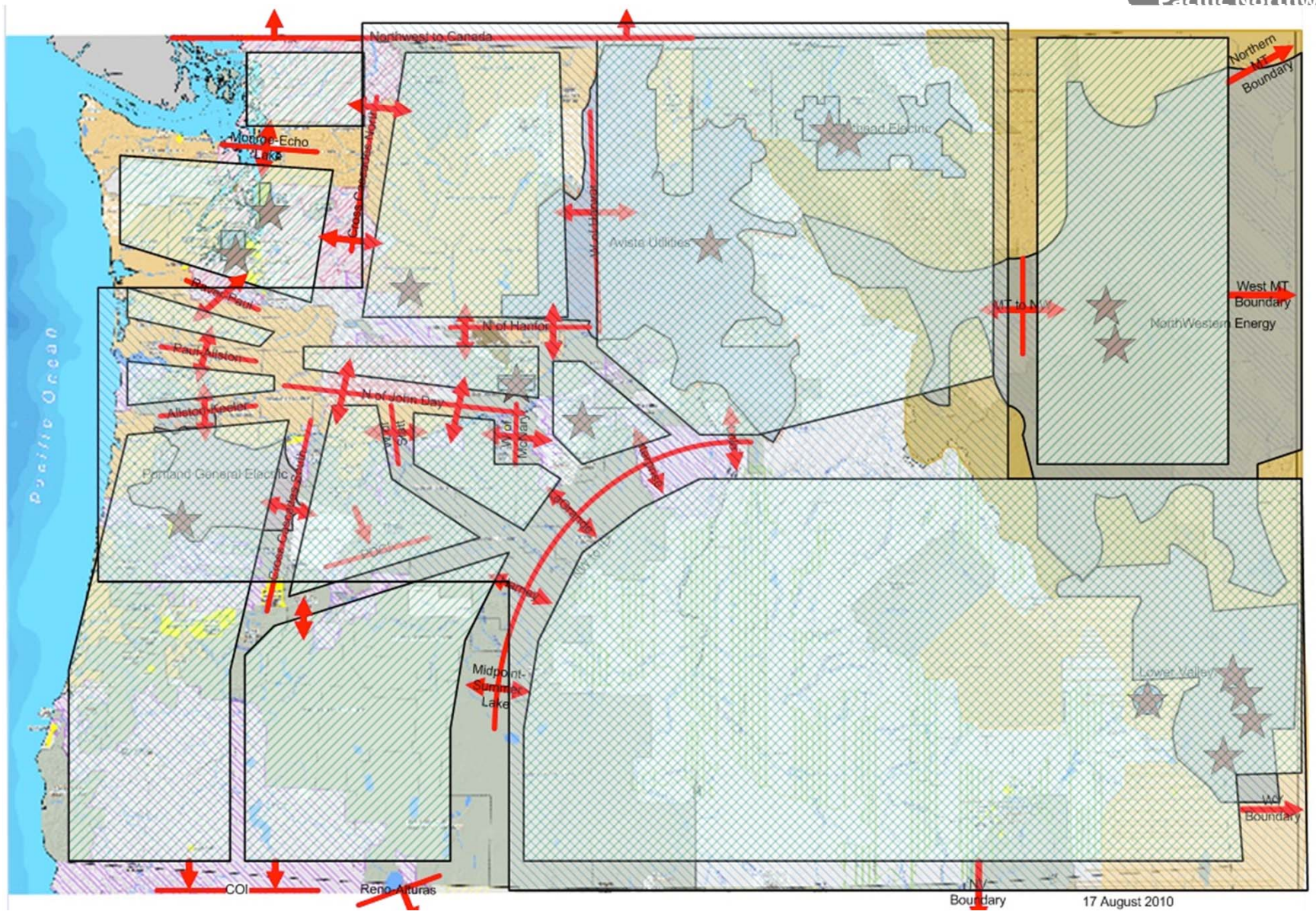
- Transactive Feedback Signal (TFS)

  A representation of the net electric load (responsive and unresponsive) at a specific system location (e.g., at a transactive node). Includes both the current value and a forecast of future values.

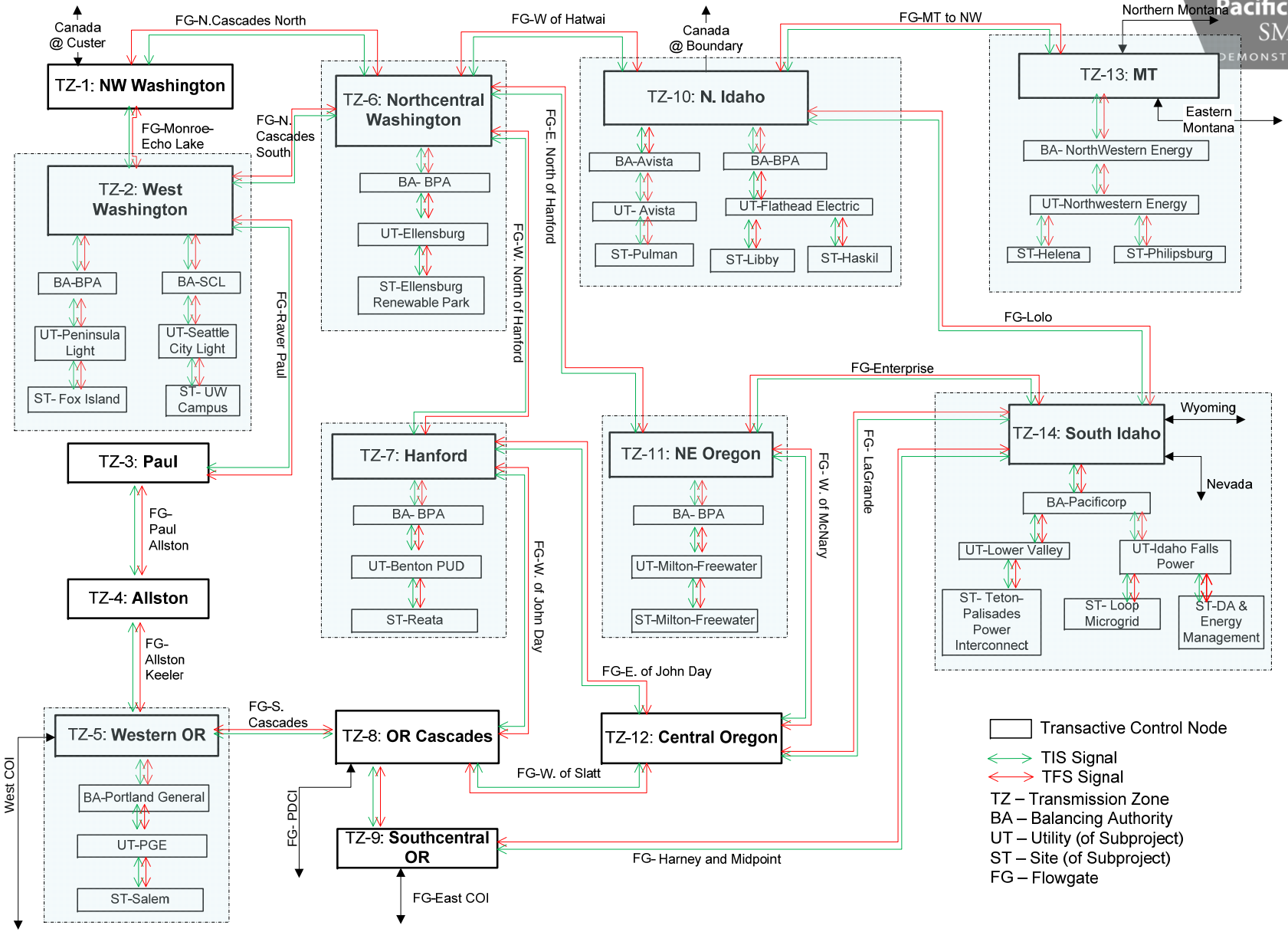
Multiscale Intervals for TIS & TFS



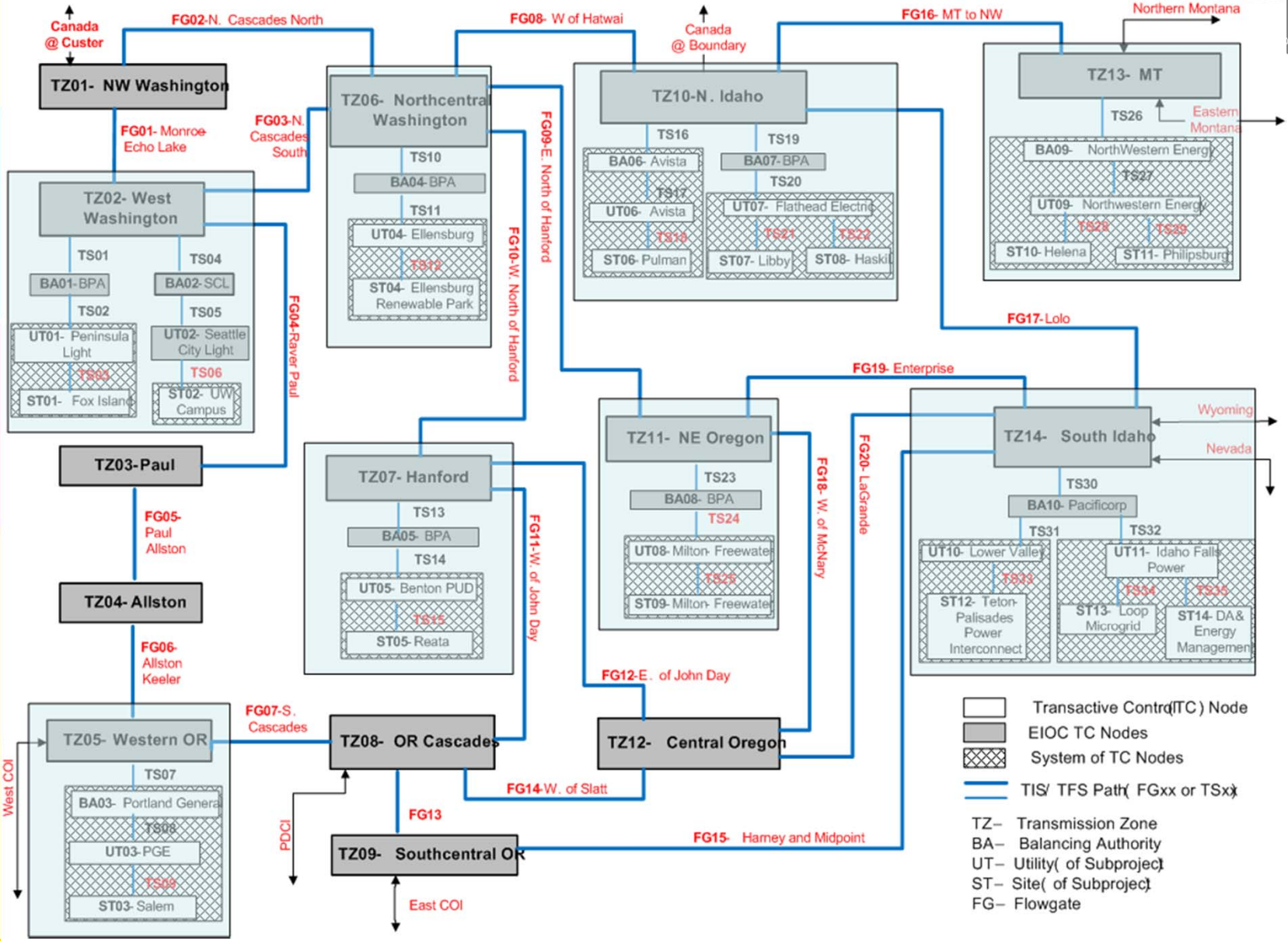
NW Region Influence Map



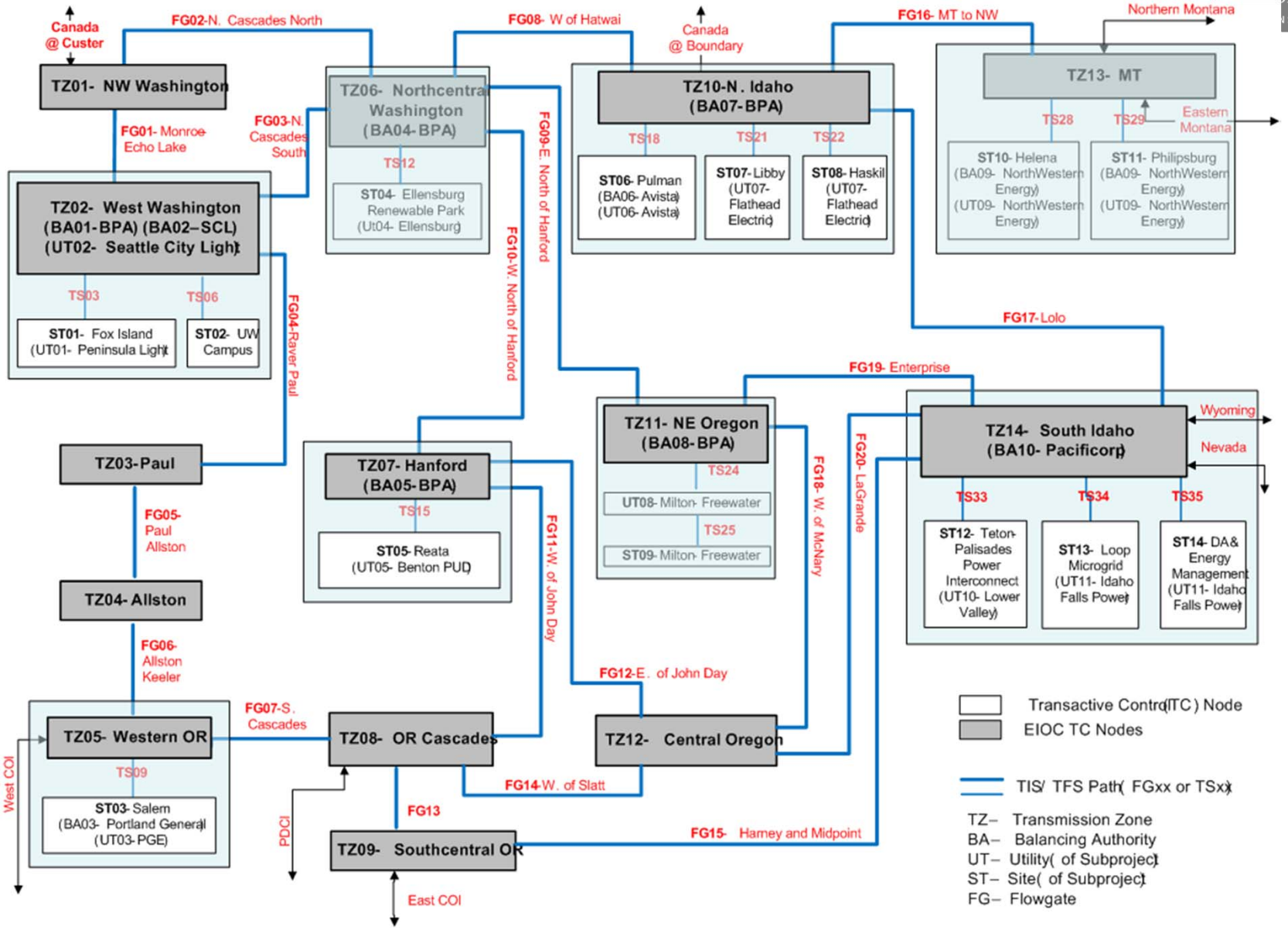
Regional and Subproject Transactive Control Nodes & Network Topology



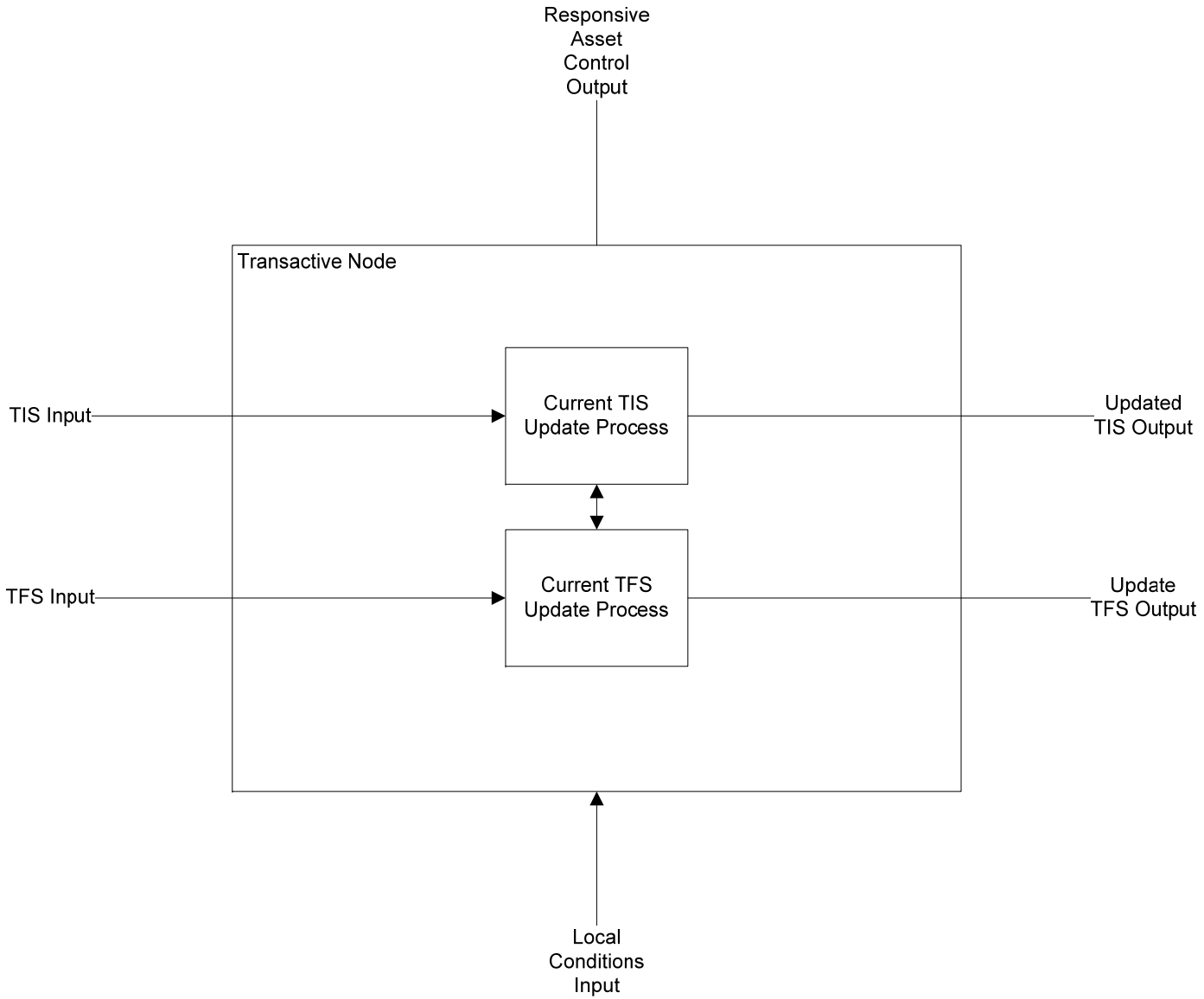
Reduced Set of Regional Nodes



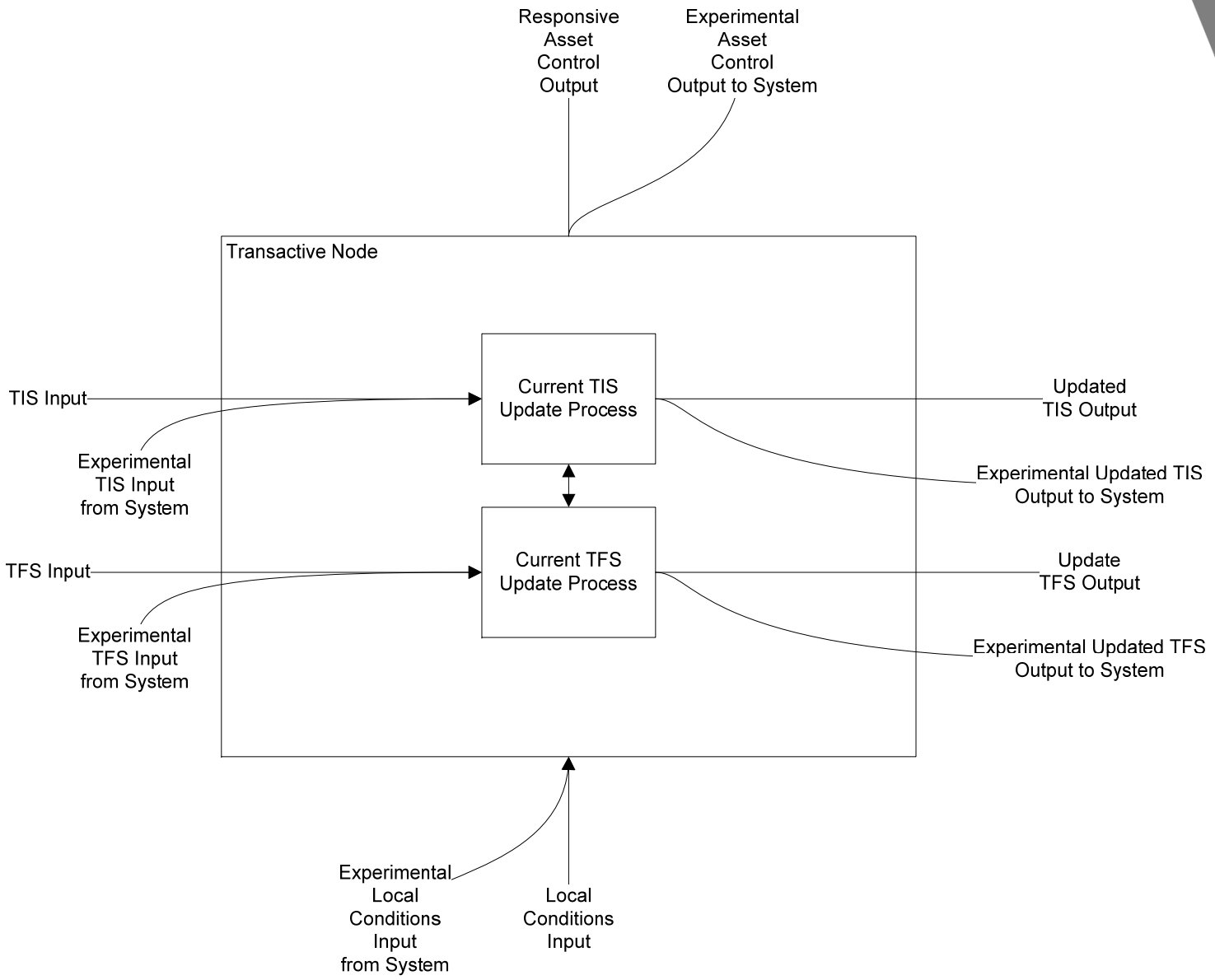
Reduced set of Regional Nodes (2)



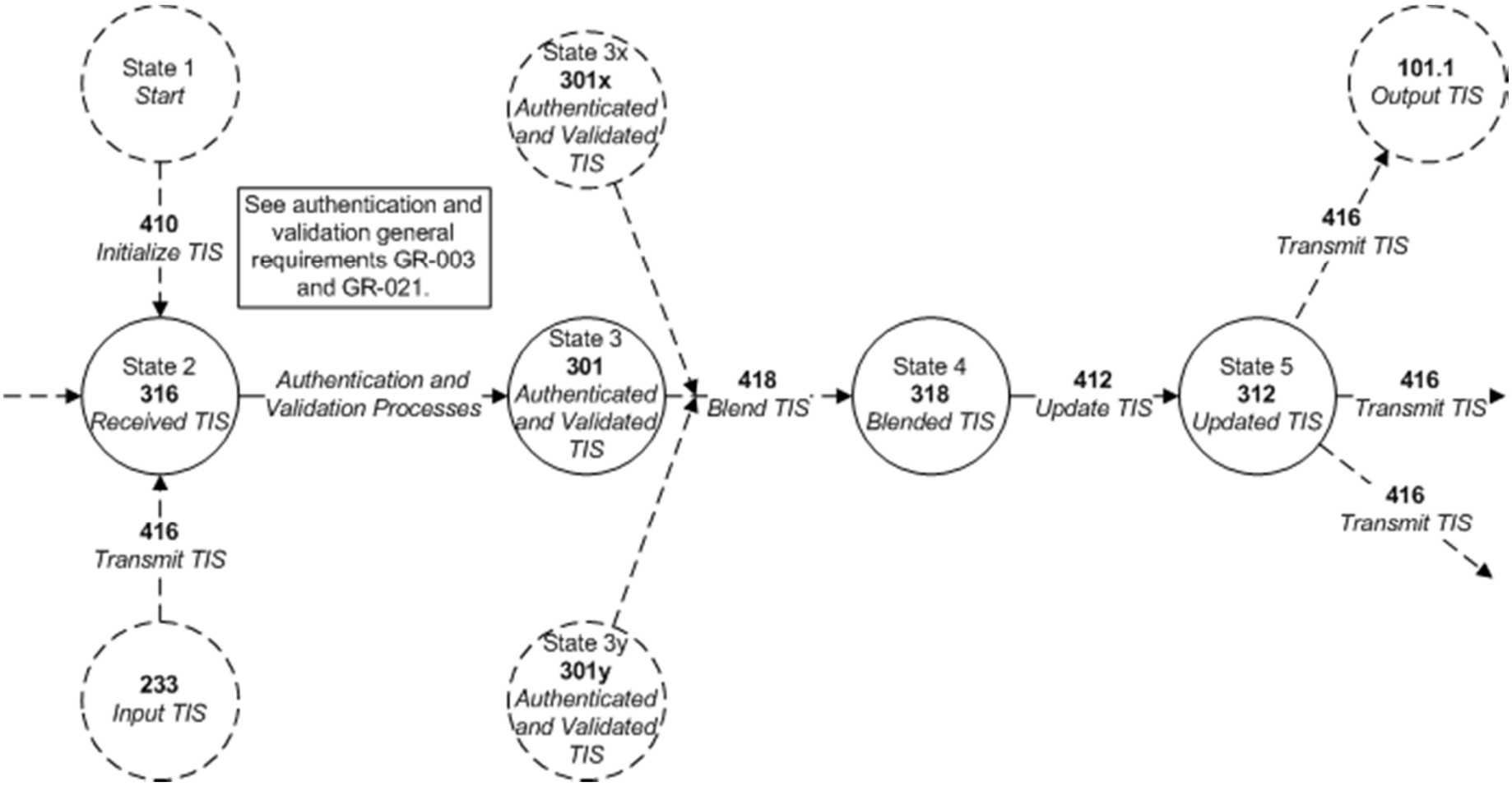
Generic Transactive Control Node



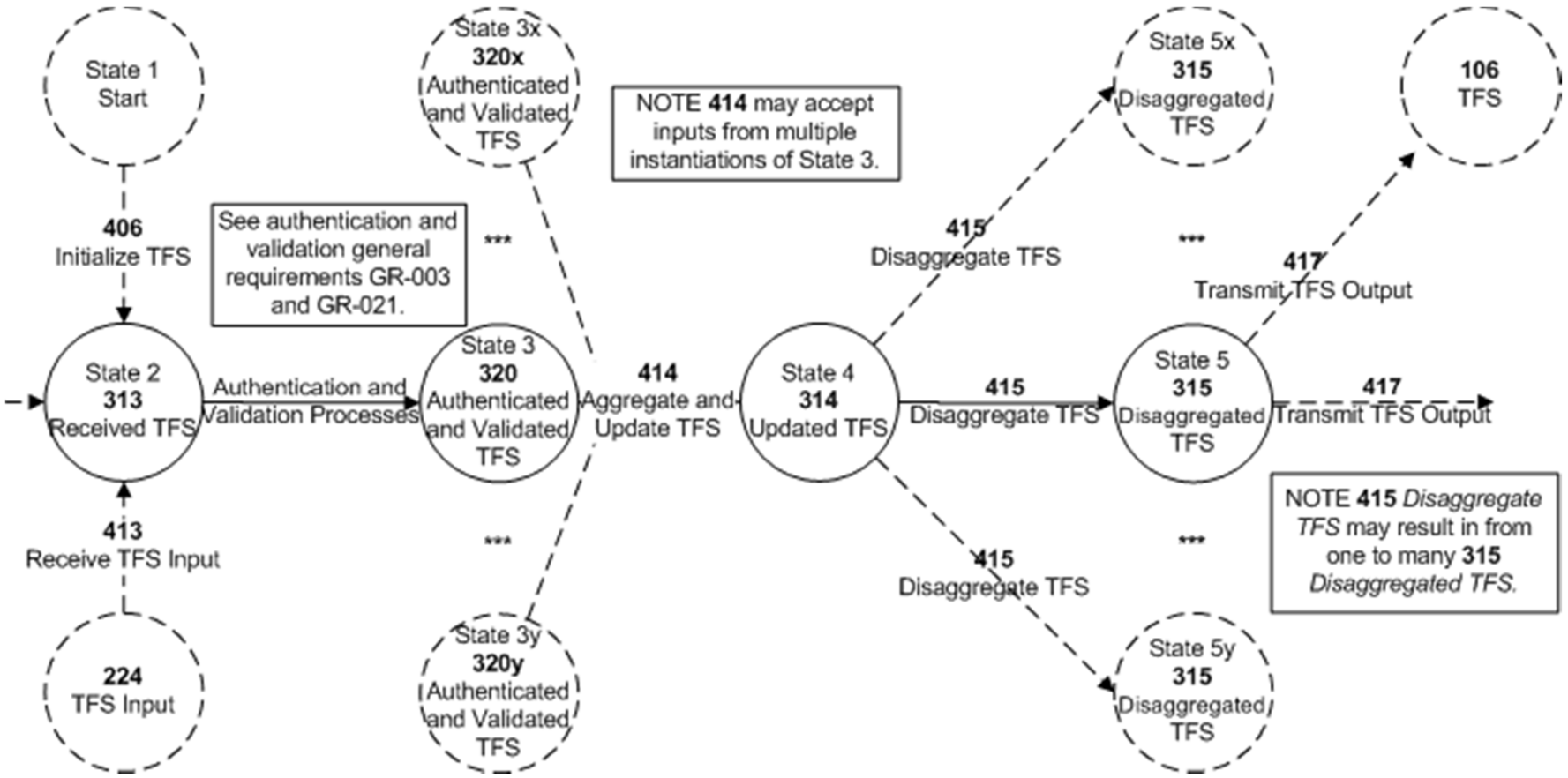
Generic Transactive Control Node +



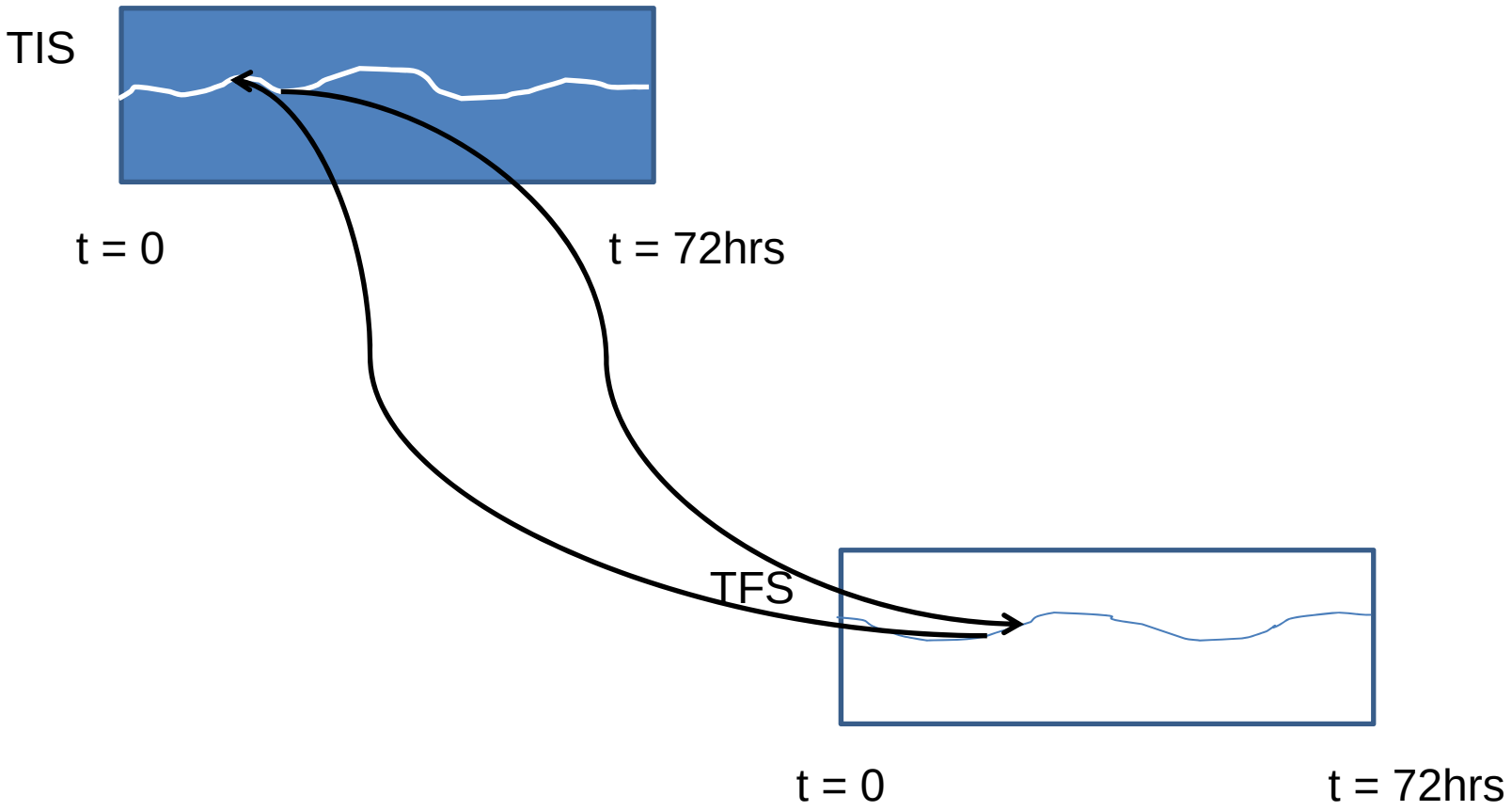
TIS Process


State 1
Start
410
Initialize TIS
See authentication and validation general requirements GR-003 and GR-021.
State 3x
301x
Authenticated and Validated TIS
101.1
Output TIS
416
Transmit TIS
State 2
316
Received TIS
Authentication and Validation Processes
State 3
301
Authenticated and Validated TIS
418
Blend TIS
State 4
318
Blended TIS
412
Update TIS
State 5
312
Updated TIS
416
Transmit TIS
416
Transmit TIS
416
Transmit TIS
233
Input TIS
State 3y
301y
Authenticated and Validated TIS

TFS Process


State 1
Start
406
Initialize TFS
State 2
313
Received TFS
413
Receive TFS Input
224
TFS Input
See authentication and validation general requirements GR-003 and GR-021.
Authentication and Validation Processes
State 3x
320x
Authenticated and Validated TFS
State 3
320
Authenticated and Validated TFS
State 3y
320y
Authenticated and Validated TFS
***
NOTE 414 may accept inputs from multiple instantiations of State 3.
414
Aggregate and Update TFS
State 4
314
Updated TFS
415
Disaggregate TFS
415
Disaggregate TFS
415
Disaggregate TFS
State 5x
315
Disaggregated TFS
State 5
315
Disaggregated TFS
State 5y
315
Disaggregated TFS
417
Transmit TFS Output
417
Transmit TFS Output
106
TFS
NOTE 415 Disaggregate TFS may result in from one to many 315 Disaggregated TFS.

TIS / TFS Interaction



Transactive Control Test Cases

- Approximately 40 TC test cases in project
- Examples include:
  - Voltage optimization
  - Load control – commercial
  - Load control – residential
  - Storage system control
  - Automated demand response
  - PHEV charging control

Implementation Challenges

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

- Easy to say, difficult to do: apply the KISS principle
- The grid as a network
  - Bulk power nodes form a mesh
  - Distribution system nodes generally more hierarchical
  - How do we assure that a sudden change in bulk power is communicated to responsive assets in a timely manner?
- Cyber security
  - Signal integrity
  - System integrity, e.g., how to handle missing data, nodes that cease to operate, etc.

Questions and Discussion

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