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Integrated Topology Processing (ITP): Unification of Operations and Planning Applications

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Outline

- History of Power System Models
- EMS and Planning Models
- Problems
- Solutions
- Integrated Topology Processing
  - What it does
  - How it works
  - Advantages

History

- Historical Problem:
  - Due to security, performance, and cost reasons, during the 70s the real-time operation and planning stages of power systems adopted different models.

Real-Time Operations
Use detailed node/breaker model
EMS system as a set of integrated applications and processes
Real-time operating system
Real-time databases

Planning
Use simplified bus/branch model
PC approach
Use of files
Stand-alone applications

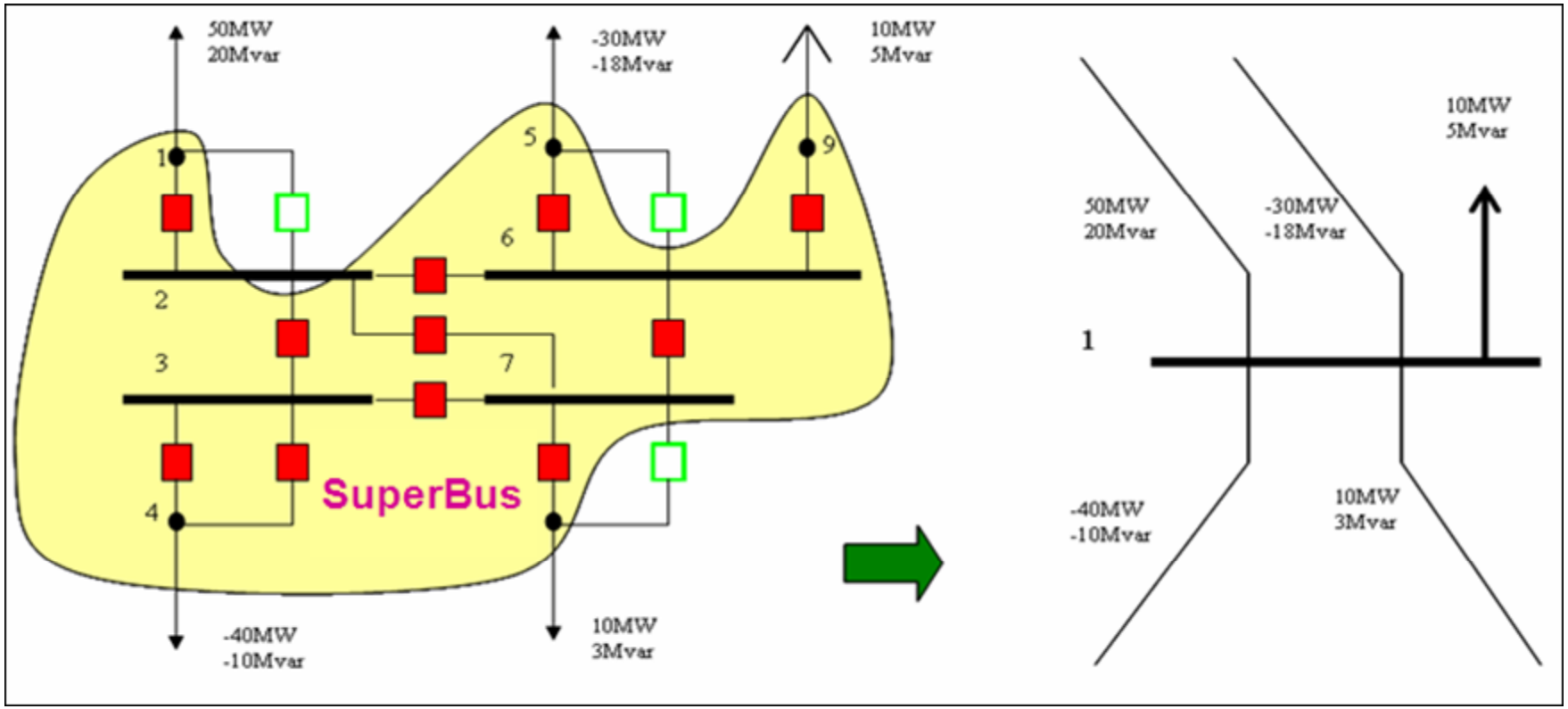
EMS and Planning Models

EMS Model

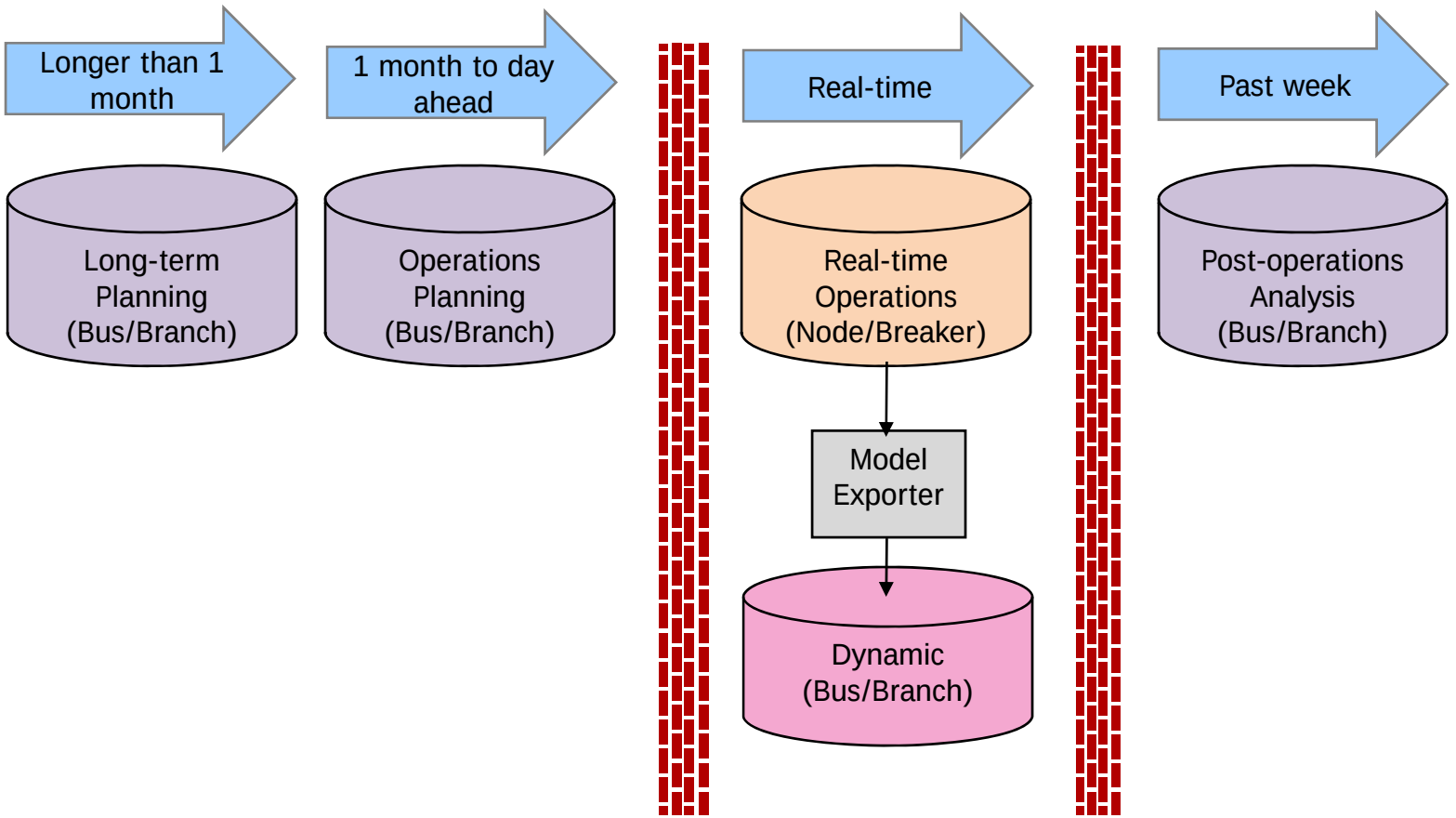
- Used for real-time operations
- Call this ***Full-Topology*** model
- Has node/breaker detail

Planning Model

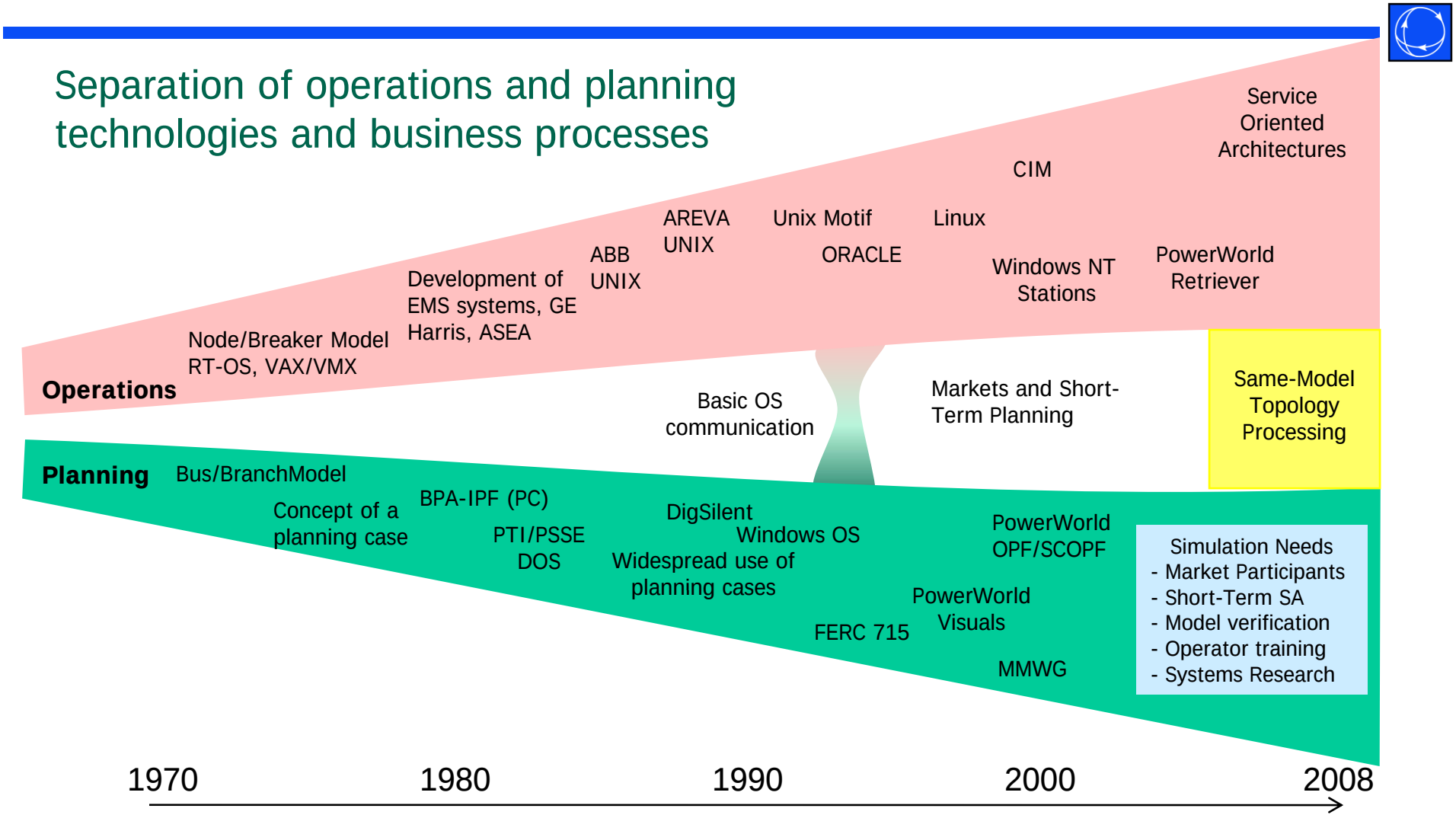
- Used for off-line analysis
- We call this ***Consolidated*** model
- Has bus/branch detail



Power Industry Business Stages



History


Separation of operations and planning technologies and business processes
Service Oriented Architectures
CIM
AREVA UNIX
Unix Motif
Linux
ABB UNIX
ORACLE
Windows NT Stations
PowerWorld Retriever
Development of EMS systems, GE Harris, ASEA
Node/Breaker Model RT-OS, VAX/VMX
Operations
Basic OS communication
Markets and Short-Term Planning
Same-Model Topology Processing
Planning
Bus/BranchModel
Concept of a planning case
BPA-IPF (PC)
PTI/PSSE DOS
DigSilent
Widespread use of planning cases
Windows OS
PowerWorld OPF/SCOPF
PowerWorld Visuals
FERC 715
MMWG
Simulation Needs
- Market Participants
- Short-Term SA
- Model verification
- Operator training
- Systems Research
1970
1980
1990
2000
2008

Existing Problems

- Different operations and planning models within the same utility
- Multiple data repositories
  - Difficult to maintain: manual processes, extensive training, etc.
- Different applications are used to solve the same problem.
- Cumbersome to compare EMS and planning results.
- EMS cases are incompatible with planning applications and vice-versa

Existing Problems

- A a planning *representation* is still needed
  - Serious numerical problems caused by large numbers of low impedance branches
- CIM and Interoperability
  - Goal is to enable exchange of information between different systems and applications
  - Provides good conventions for identifying devices and attributes and their relationship to other devices
  - Still requires separate models and hence different applications for planning and operations

Requirements of Full Unification

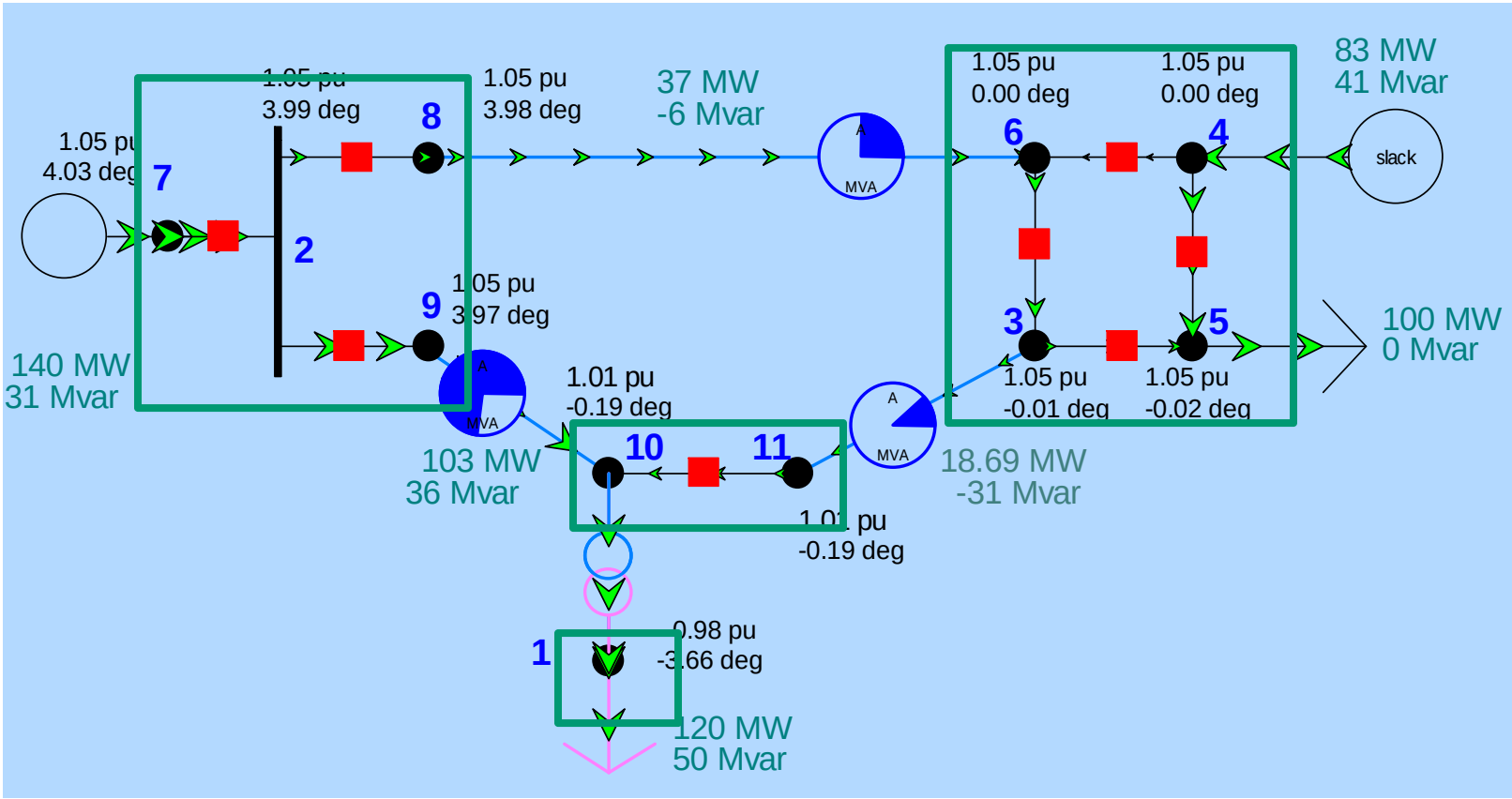
- Single model for operations and planning
- Same application capable of performing the same type of analysis in operations and planning stages
- Seamless exchange of data between planning and operation
- Solution tracking ability for diverse temporal, study, or contingency scenarios

Our Solution: Integrated Topology Processing

- Integrated Topology Processing (ITP) is a new concept that extends analysis capabilities to simulate real-time cases with the same detail and performance of EMS applications, while providing the basis for full unification.

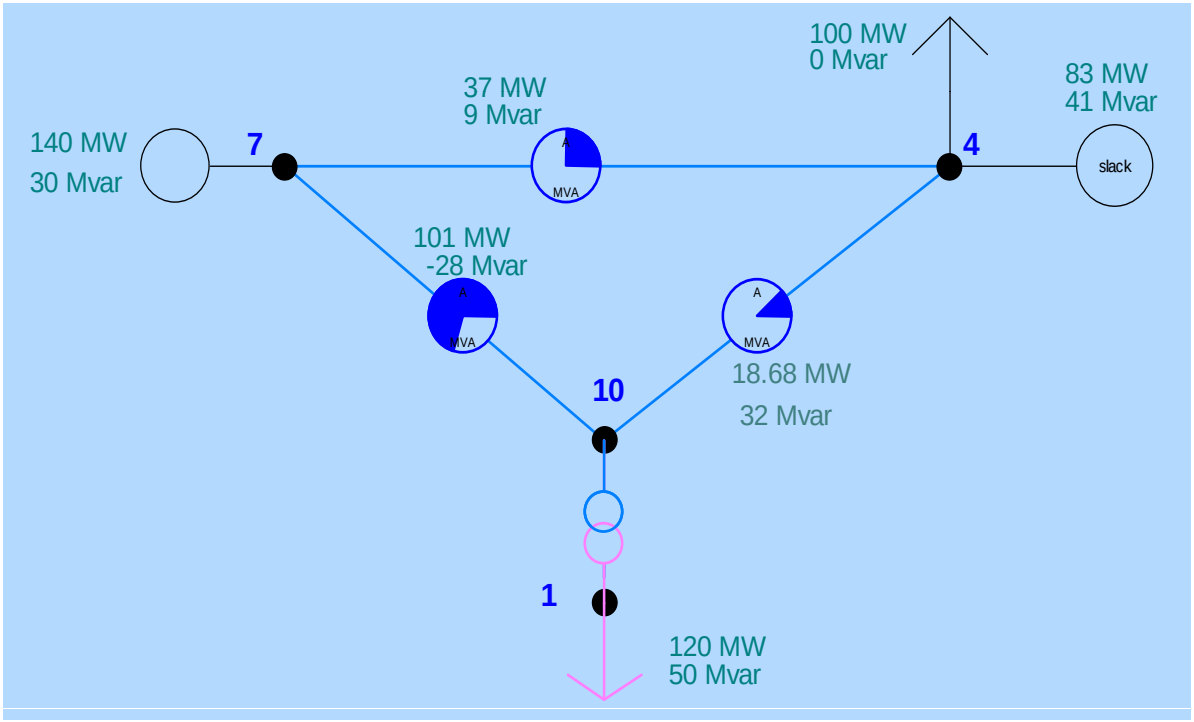
Simple Example of Modeling

– Full-topology, 11-node model with 4 superbuses



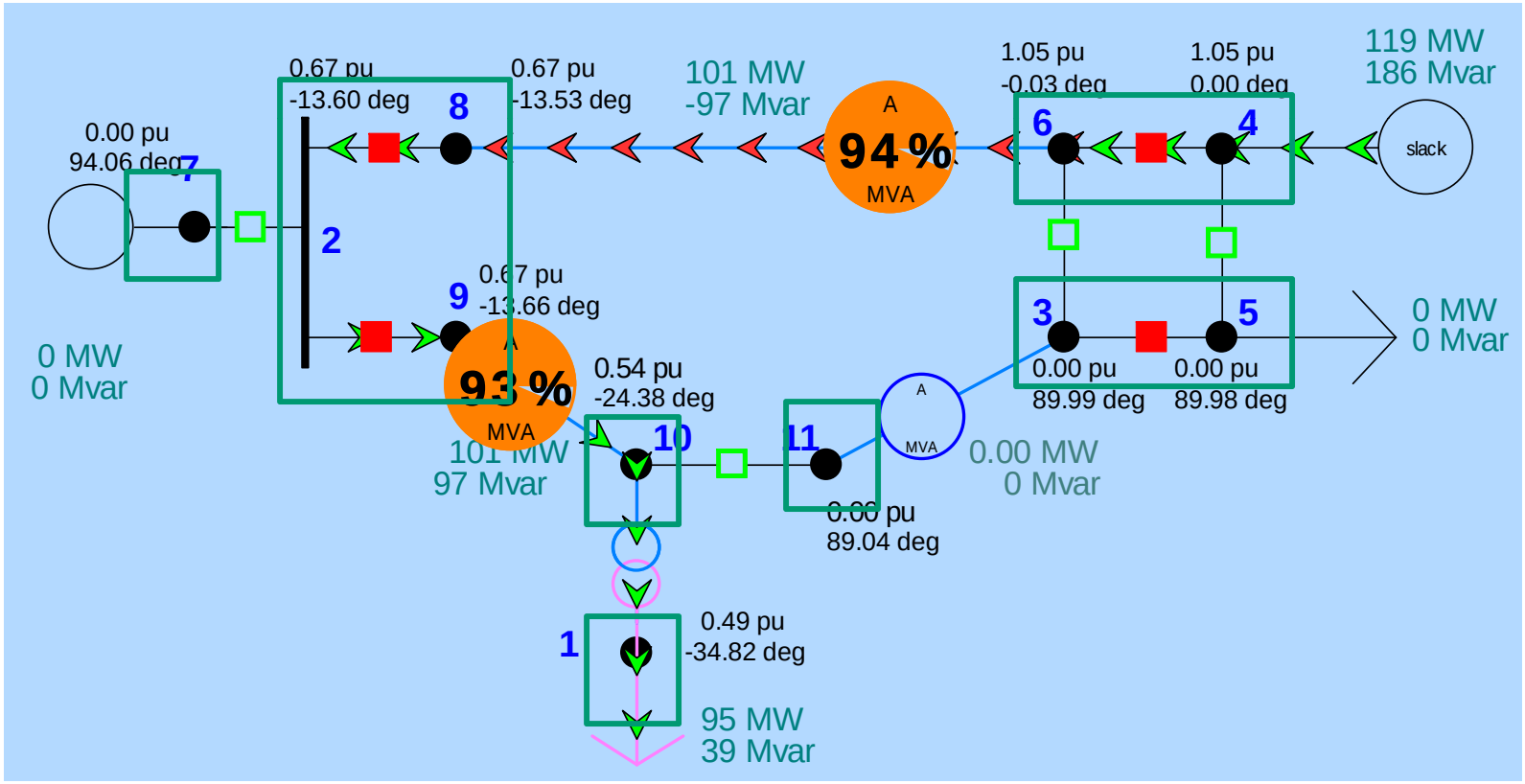
Simple Example of Modeling

- The equivalent planning model has 4 buses



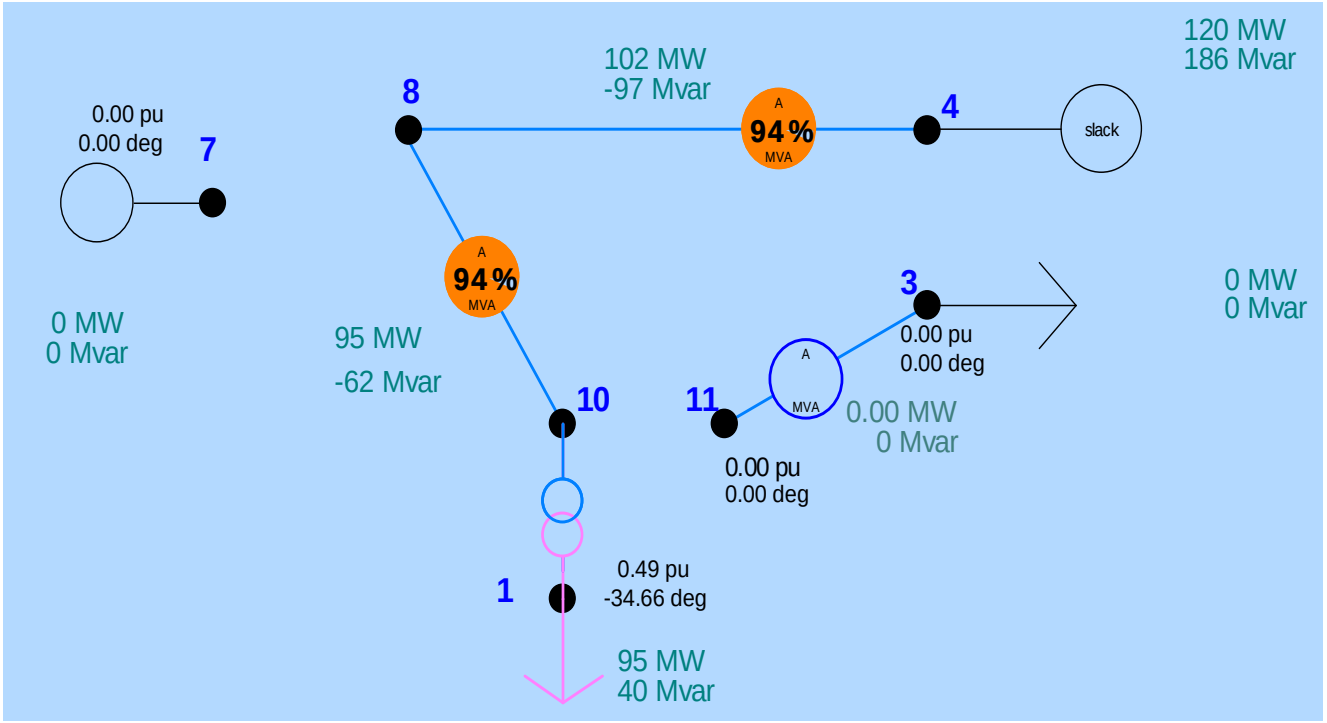
Simple Example of Modeling

– Same 11-node model with 7 superbuses



Simple Example of Modeling

- Equivalent planning model with 7 buses

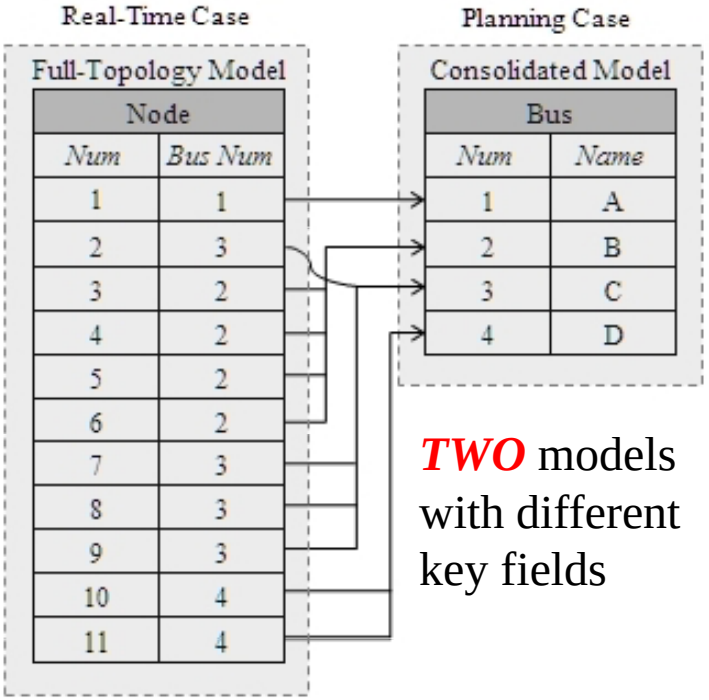


FT11_Node.pwb

How Does ITP Work?

Traditional EMS TP

Converts the full-topology model into a planning model



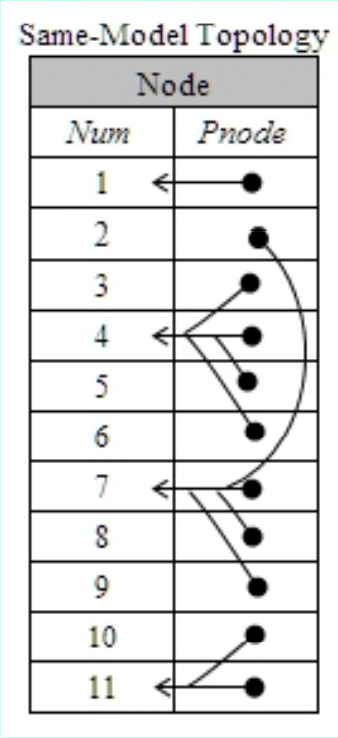
TWO models with different key fields

ITP

Needs only one model: full-topology

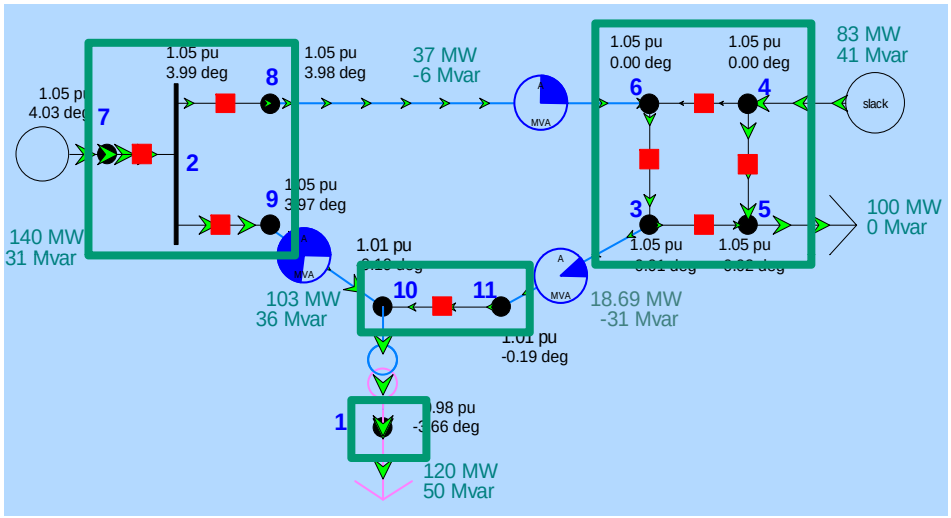
Uses dynamic device relocation

ONE model

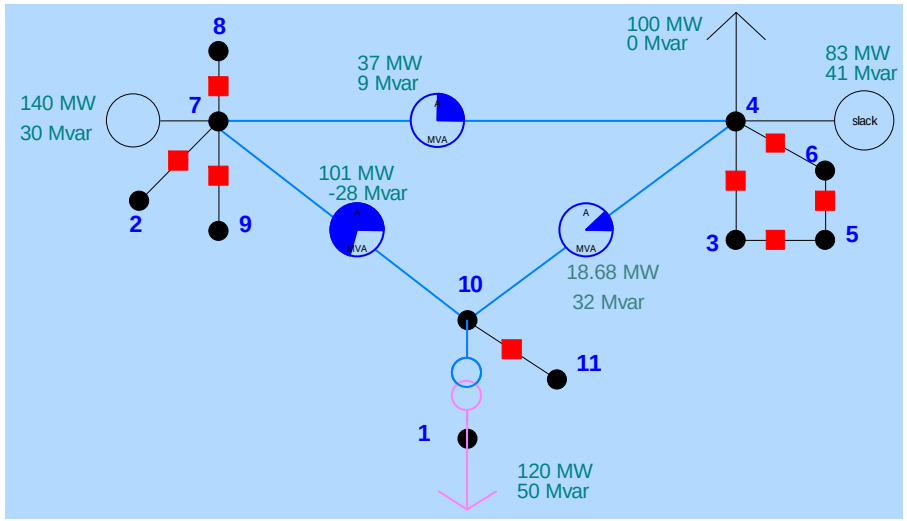


How Does ITP Work?

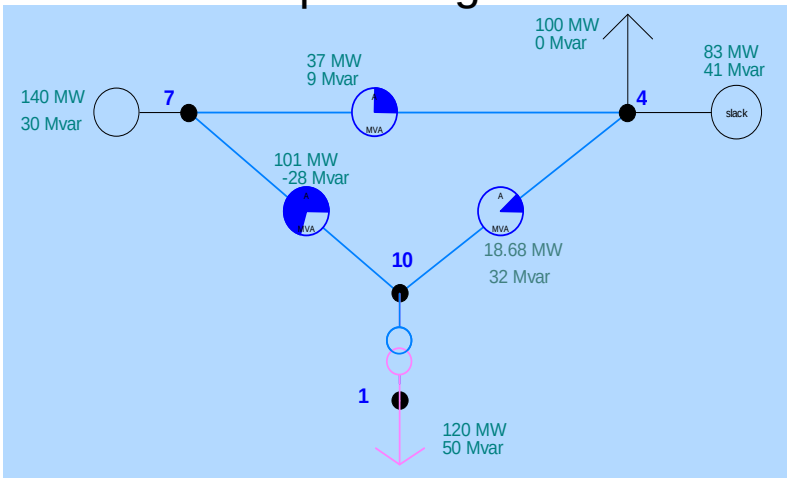
Full-topology model and superbuses



Dynamic device relocation



Consolidated planning case



Note: this is just for illustration, you would never “see” this in the software tool

Why Does ITP Work?

- Moving around pointers in memory to “consolidate” is really fast
- We’ve tested a model that had 80,000 nodes and consolidates to about 10,000 buses
  - Full consolidation takes less than 0.2 seconds
- In contingency analysis, we can be clever and do “incremental consolidation” which only takes in the order of 0.001 second (1 ms) per contingency

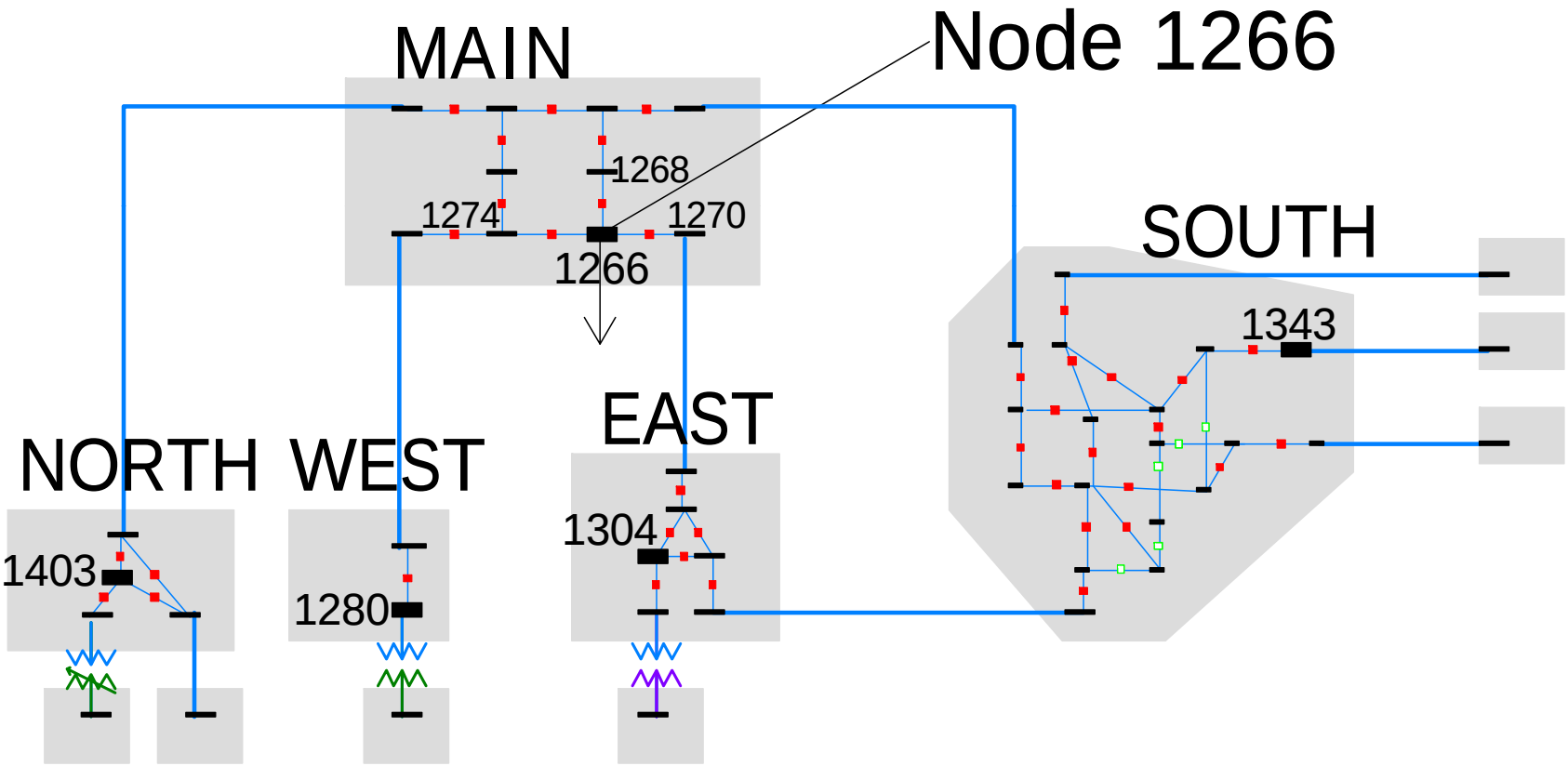
Three Levels of Unification

1. FORMAT: use the traditional planning format (RAW, EPC, IEEE, AUX, etc.)
   - It will just include a large number of low-impedance branches
   - CIM will be another format
2. MODEL: use the full-topology model
3. APPLICATION: No changes required to the core numerical applications. Just use the consolidation and de-consolidation strategy.

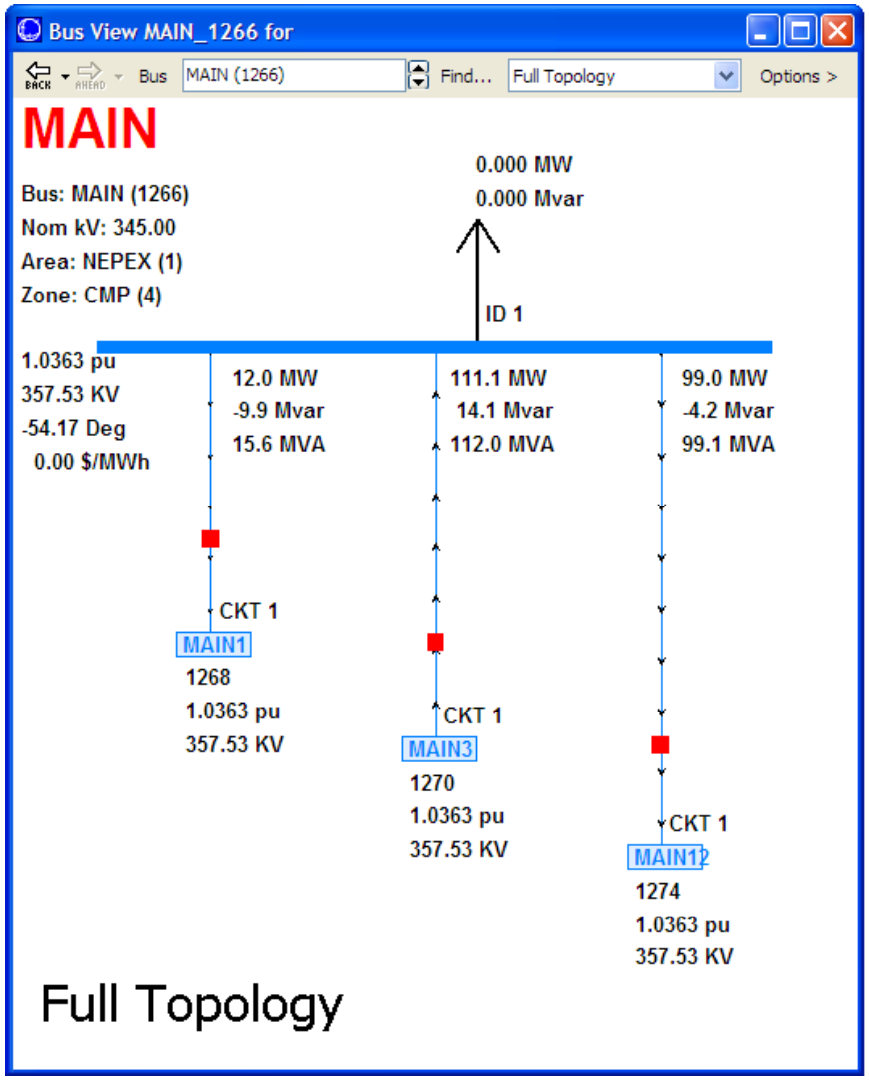
Planning with Full-Topology Models

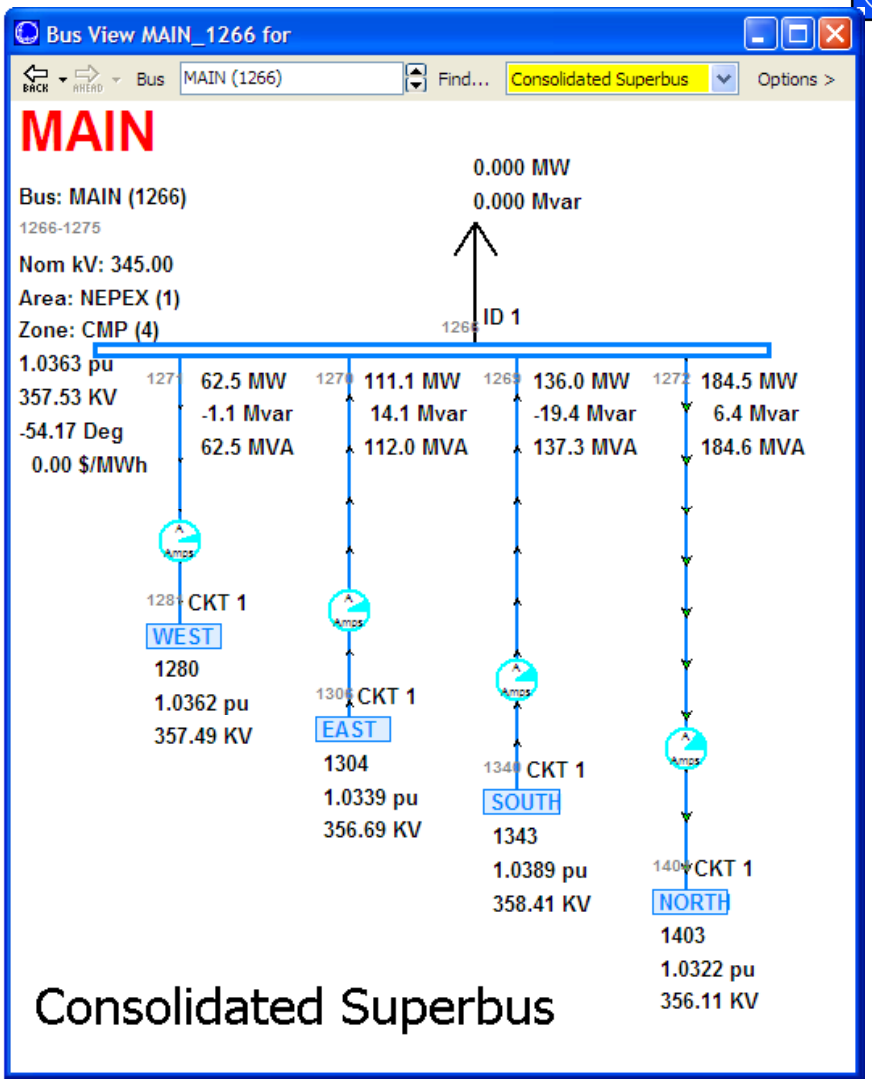
- New model is larger than the planning model
  - Planners are not used to this
  - Most of the branches in the model are breakers, disconnects, etc…
- Navigating the model node by node will be cumbersome

Viewing the Models

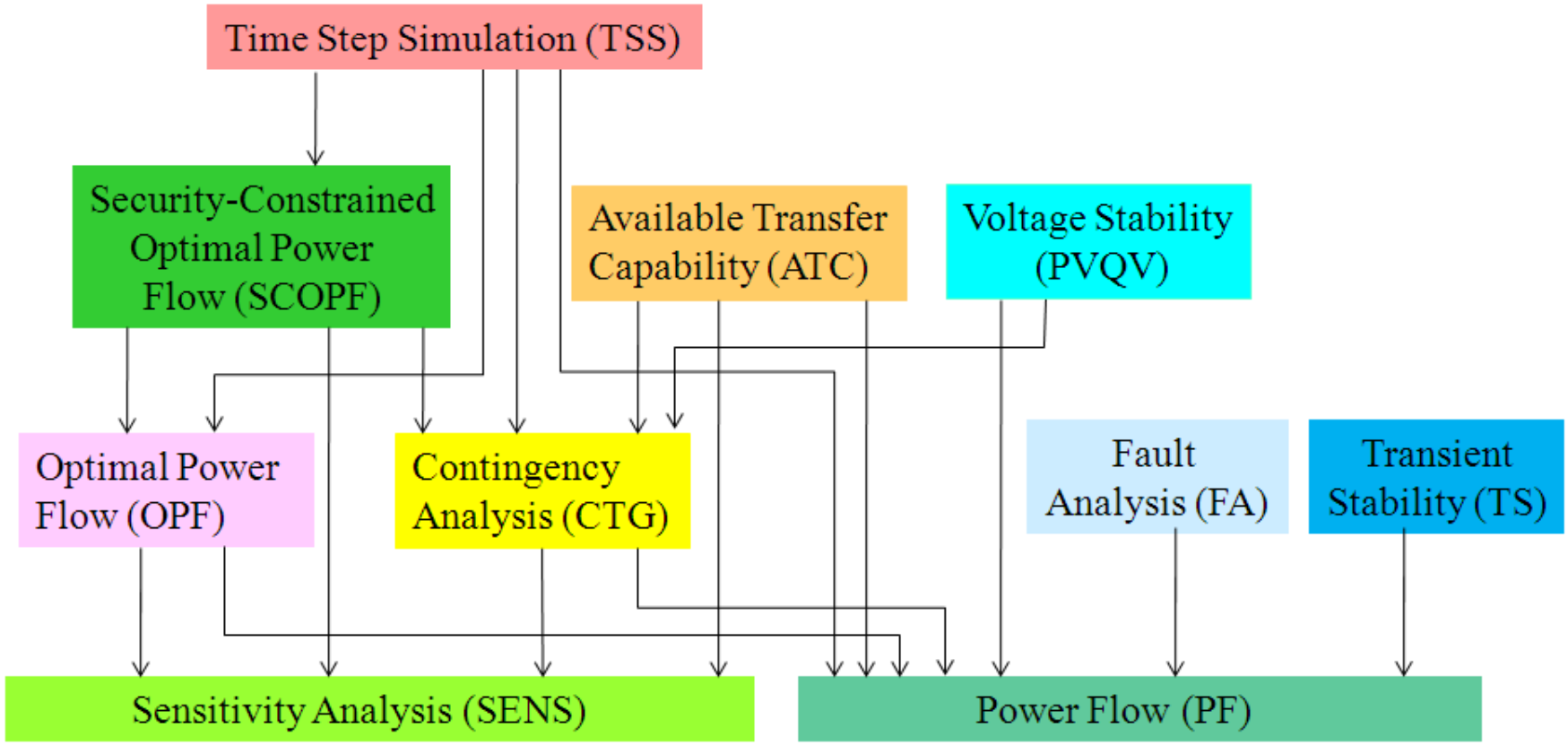


Bus View


Bus View MAIN_1266 for
Bus
MAIN (1266)
Find...
Full Topology
Options >
MAIN
Bus: MAIN (1266)
Nom kV: 345.00
Area: NEPEX (1)
Zone: CMP (4)
1.0363 pu
357.53 KV
-54.17 Deg
0.00 $/MWh
0.000 MW
0.000 Mvar
ID 1
12.0 MW
-9.9 Mvar
15.6 MVA
111.1 MW
14.1 Mvar
112.0 MVA
99.0 MW
-4.2 Mvar
99.1 MVA
CKT 1
MAIN1
1268
1.0363 pu
357.53 KV
CKT 1
MAIN3
1270
1.0363 pu
357.53 KV
CKT 1
MAIN12
1274
1.0363 pu
357.53 KV
Full Topology


Bus View MAIN_1266 for
Bus
MAIN (1266)
Find...
Consolidated Superbus
Options >
MAIN
Bus: MAIN (1266)
1266-1275
Nom kV: 345.00
Area: NEPEX (1)
Zone: CMP (4)
1.0363 pu
357.53 KV
-54.17 Deg
0.00 $/MWh
0.000 MW
0.000 Mvar
ID 1
62.5 MW
-1.1 Mvar
62.5 MVA
111.1 MW
14.1 Mvar
112.0 MVA
136.0 MW
-19.4 Mvar
137.3 MVA
184.5 MW
6.4 Mvar
184.6 MVA
CKT 1
WEST
1280
1.0362 pu
357.49 KV
CKT 1
EAST
1304
1.0339 pu
356.69 KV
CKT 1
SOUTH
1343
1.0389 pu
358.41 KV
CKT 1
NORTH
1403
1.0322 pu
356.11 KV
Consolidated Superbus

Application Integration



Same-Model TP Advantages

- Ability to use planning applications directly in the real-time production environment:
  - Simulator PF, CTG Analysis, OPF, SCOPF, ATC, Voltage Stability, Transient Stability
- Ability for planners to work directly on, and fully study, the real-time system in off-line environment.
- Seamless exchange of data between planning and operation.
- Full interoperability of EMS and planning at the study and contingency solution level.

Same-Model TP Advantages

- Work with One Model
  - No need of new format
  - No need to learn multiple models
  - No need of model translators
- Smooth transition for planners
  - For the user it is transparent to work on a full-topology or planning case

Projects

- ISONE, Completed March, 2008
- GXED, China, Finished August, 2008
- TransGrid, Australia, Finished November, 2008
- BPA (Transient Stability Integration), Ongoing
- TVA (ITP Application Automation), Ongoing
- SCANA, Integration to begin soon.