Open Model For Exchanging Power System Data

Prof. Dr. Federico Milano

E-mail: Federico.Milano@uclm.es

Universidad de Castilla - La Mancha

España

Dr. Mike Zhou

E-mail: mike@interpss.org

TIBCO Software, Inc.

Palo Alto, CA, USA

Mr. GuanJi Hou

E-mail: stephen@interpss.org

South China University of Technology

Guangdong, China

Universidad de Castilla-La Mancha, InterPSS

Bio. - Federico Milano

- Federico Milano received from the University of Genoa, Italy, the Electrical Engineering degree and the Ph.D. degree in 1999 and 2003, respectively.
- From 2001 to 2002 he worked at the University of Waterloo, Canada, as a Visiting Scholar.
- He is currently an associate tenured Professor at the University of Castilla-La Mancha, Ciudad Real, Spain.
- His research interests include voltage stability, electricity markets and computer-based power system analysis and control.

Bio. - Mike Zhou

- Ph.D. Tsinghua University, 1987. Currently a senior computer system architect with TIBCO Software, Inc., Palo Alto, CA, USA. He is also the architect of the InterPSS project.

Bio. - GuanJi Hou

- GuanJi Hou received the B.S. degree in electrical engineering from Electric Power College, South China University of Technology, Guangdong, China, in 2006. Since then, he has been studying at the South China University of Technology for the M.S. degree. Currently, he is a member of InterPSS development team. His main field of interest includes computer-based and expecially grid-computing-based power system simulation and analysis.

Contents

- Motivations
- Background
- Open Data Model
- Example
- Conclusions

Motivations I

- The IEEE recommended a Common Data Format (IEEE CDF) for exchanging power flow data date back to the early seventies.
- Unfortunately, the IEEE CDF is not flexible and is limited to static data.
- These facts make this format not suitable for storing dynamic and market information.
- Besides, software companies uses their own internal data format. Most of these formats are proprietary and generally are not freely documented.

Motivations II

- We think that the power system community needs a modern, completely free, flexible and well-documented format for power system analysis data exchange.
- The extensible markup language (XML) is a natural choice since it has reached a very mature technology and has become a world-wide standard for exchanging and sharing information.
- A huge variety of open-source XML processing tools are freely available.
- Surprisingly enough, the power system community is one of the very few scientific and technical areas were XML is not widely used.

Background I

- Among all existing formats, one can identify a few basic groups.
- The taxonomy can be made based on different features.
  - The way data are stored, organized and structured.
  - The kind of data and analysis supported.
  - The number of files that compose the full system data set.
  - The way default data and data manipulation is handled.

Ways for Storing, Organizing and Structuring Data

- *Fixed position, fixed order.* For example: UCTE, IEEE CDF, Eurostag, EPRI.
- *Free position, fixed order.* For example: PSS/E, GE-PSLF.
- *Free position, free order.* For example: Simpow, DigSilent, PSAT.
- The XML schema provides flexibility, scalability while maintaining a schematic structure.

Kind of Data and Analysis Supported

- *Static Data.* (e.g. power flow data).
- *Dynamic Data.* (e.g. synchronous machine and regulator parameters).
- *Market Data.* (e.g. generator and load bids).
- *Short Circuit Analysis Data.* (e.g. negative and zero sequence of generators and transformers).
- *Graphical Data.* (e.g. network scheme, geographical information system, etc.).
- *Other Data.* (e.g. FACTS data, user defined component data, etc.).

Number of Files that Compose the Full System Data Set

- *Single file.* Most of the data formats requires a single file for defining the whole network. This is typical of most formats.
- *Multiple fixed number of files.* Some formats uses different files for different information. For example the power flow data is separated from the dynamic data (e.g. CYME and Eurostag).
- *Any number of files.* SIMPOW provides the possibility of including any number of files. This feature is useful in case of large networks, where the amount of data is cumbersome.

Default Values and Data Manipulation

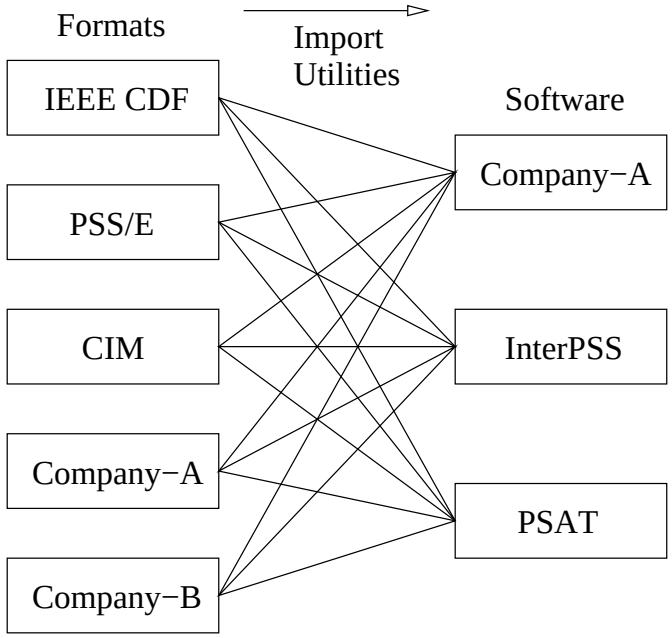
- *Default Values.* Most formats, especially fixed position formats, does not support default values and force writing all data of a component, even if those data are not known or could be easily deduced by default.
- *Device Prototyping.* An advanced evolution of default data is the device prototyping. This feature is only provided by the DigSilent format.
- *Modification Command.* Some formats provide a set of commands for modifying the *base case* data. For example Simpow provides the powerful ALTER command.
- Formats based on scripting languages, such as Matlab, implicitly include modification commands, since any Matlab function and matrix manipulation can be included in the data file.

Background II

- Available formats (not complete!): Aspen, CEPEL, CYME, DigSilent, EPRI/BPA, Etap, Eurostag, FlowDemo.net, GE-PSLF, IEEE CDF, INPTC1, InterPSS, MatPower, Neplan, PowerWorld, PSAT, PSS/E, PST, Simpow, UCTE, etc.
- Due to the high number of available formats, if one wants to use different software tools, one has to use some data import/export utilities.

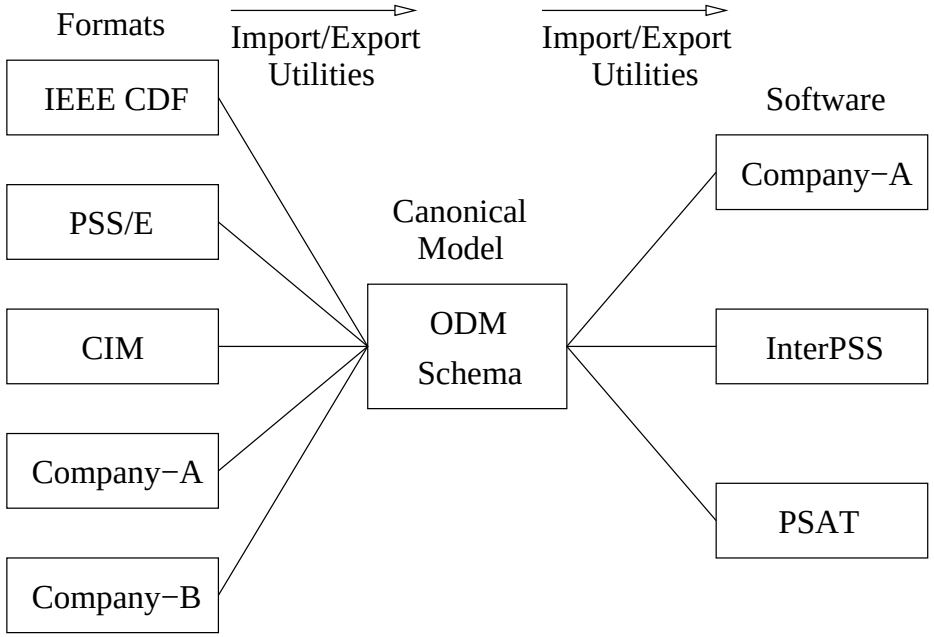
Current Import/Export Utilities

- The current way of importing and exporting data is quite expensive.
- If there are n data formtas and m applications, the number of possible conversion is $n \cdot m$!



Proposed Import/Export Utilities

- The proposed ODM is able to solve this issue, given that this schema becomes widely accepted by the power system community and by software companies.
- Using the ODM model, the possible filtering/converting routes for n formats and m applications are only $n + m$.



Universidad de Castilla-La Mancha, InterPSS

Open Data Model

- The proposed ODM is specified by an XML schema intended for power system simulation.
- The ODM does not pretend to replace CIM models, but rather to provide a complementary tool.
- The main purpose is for power system analysis: power flow, optimal power flow, time domain simulations, etc.

Basic Concepts of the Open Data Model

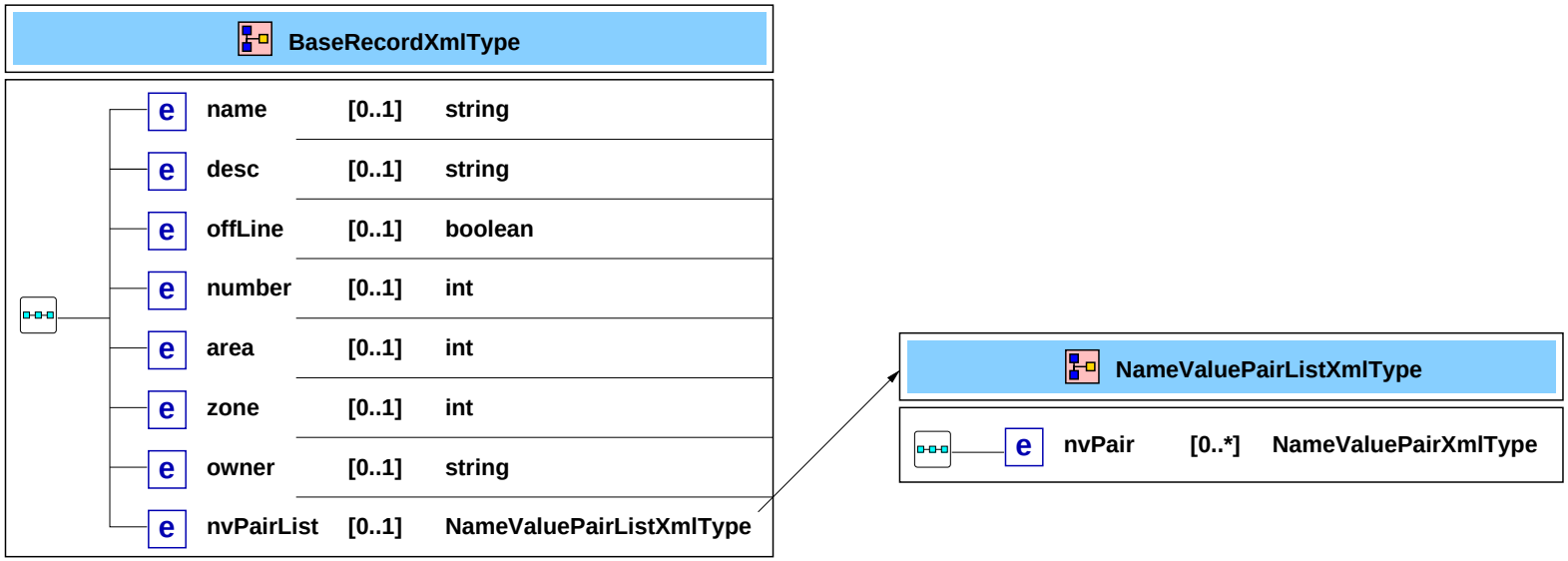
- Records.
  - Attributes.
  - Power system Data (bus record, branch record, etc.).
  - Case Study (base case, scenarios, etc.).
- Naming convention.
- Units.

Records

- The smallest unit of information is a record.
- Each record has certain common attributes, such as name, description, status, etc.
- A minimal power system data file is a set of bus records and branch records, with the branch records “connecting” to two or more bus records to form a network.

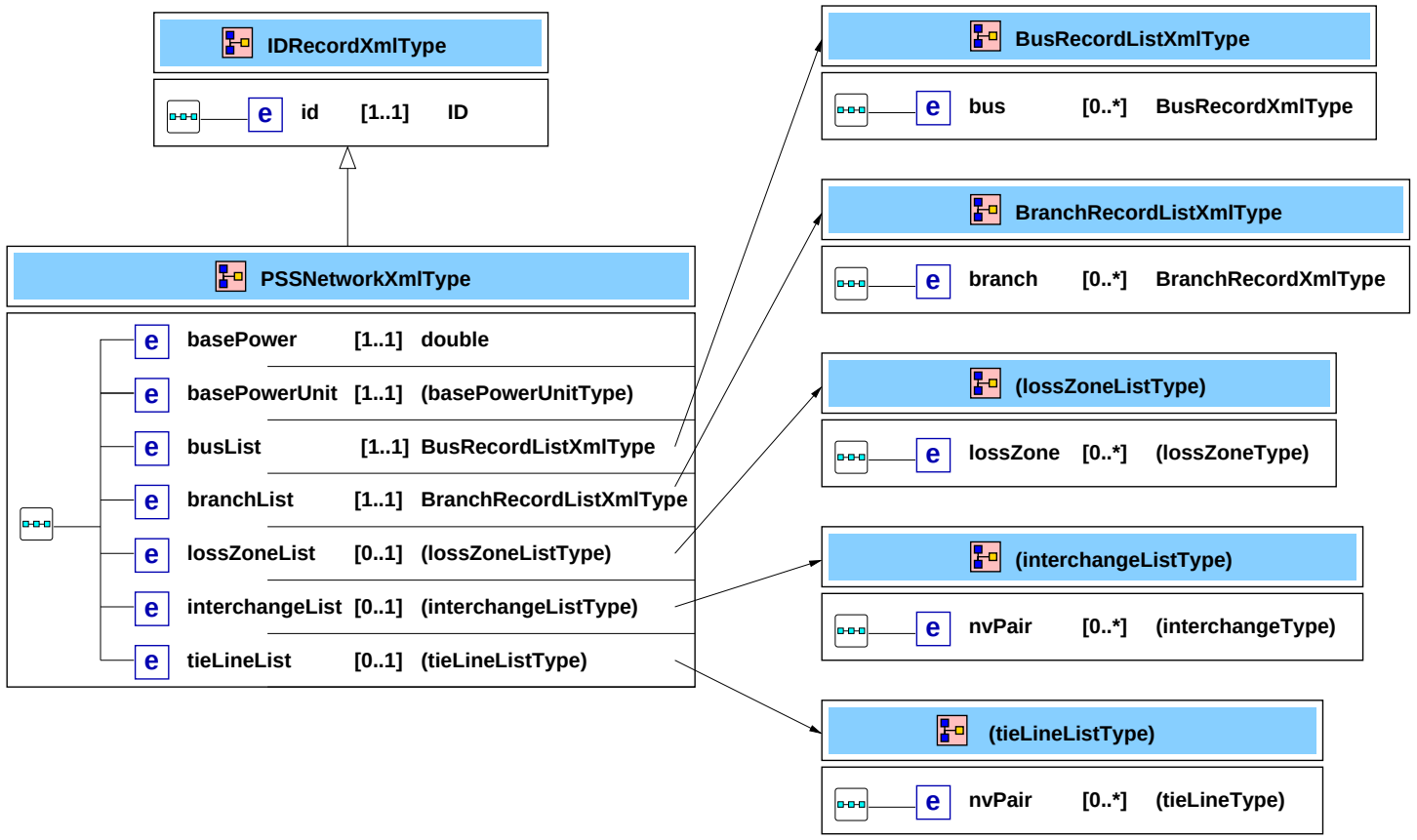
Prototype of Base Record

- Prototype of base record in XML format.



Network Record

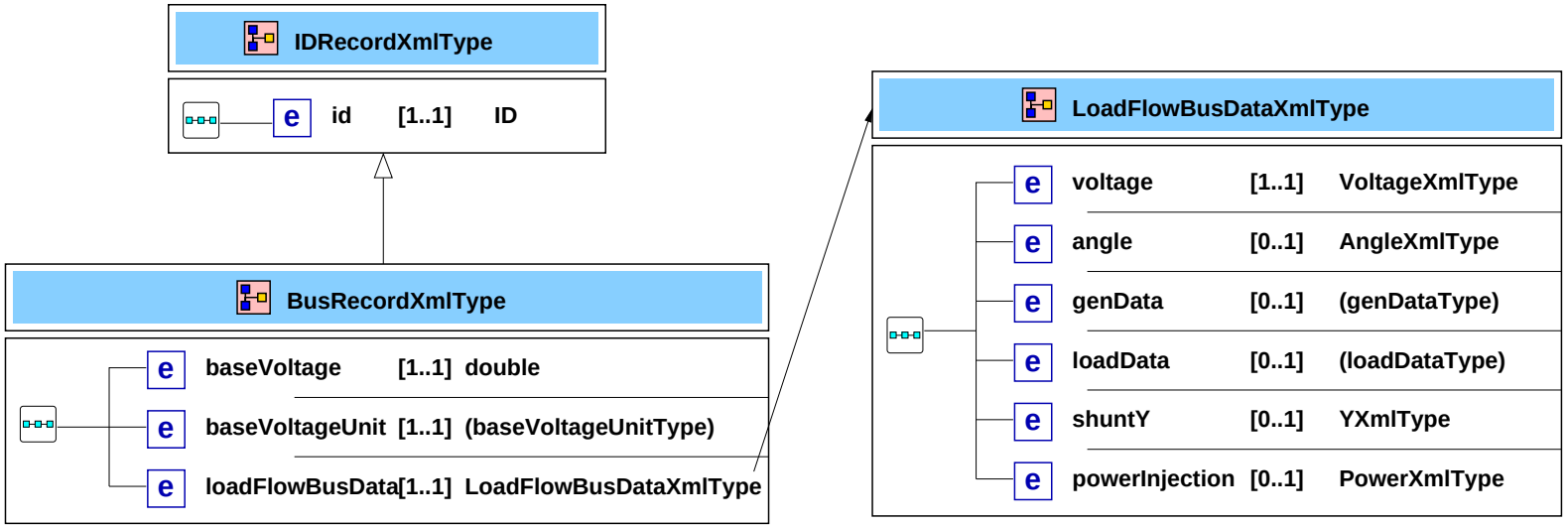
- The network record is a box that contains all network devices.



Universidad de Castilla-La Mancha, InterPSS

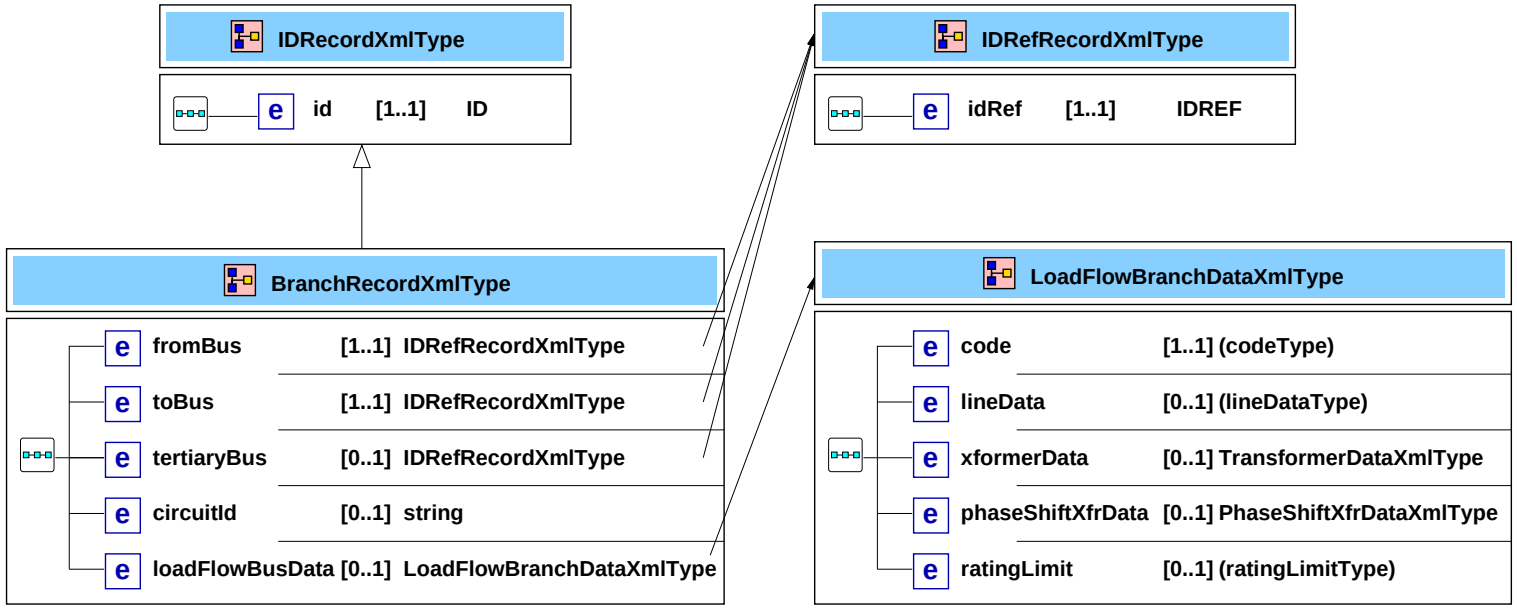
Bus Record

- Bus record structure and attributes:



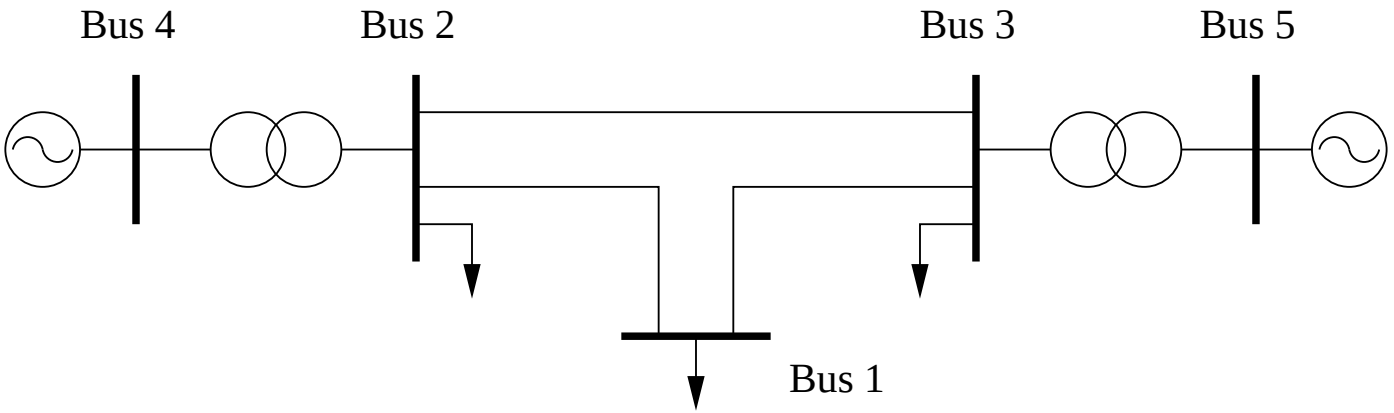
Branch Record

- Branch record structure and attributes:



Example

- One-line diagram of the 5-bus test sample.
- We presents some chunks of XML codes.
- ODM data files are created by specific XML editors, not by hand!



Example - Header Data

```
<?xml version="1.0" encoding="UTF-8"?>
<pss:PSSStudyCase>
 <pss:id>5Bus-Sample-System</pss:id>
 <pss:schemaVersion>V1.00</pss:schemaVersion>
 <pss:originalFormat>IEEE-ODM-PSS</pss:originalFormat>
 <pss:analysisCategory>Loadflow</pss:analysisCategory>
 <pss:networkCategory>Transmission</pss:networkCategory>
 <pss:baseCase>
   <pss:id>Base-Case</pss:id>
   <pss:basePower>100.0</pss:basePower>
   <pss:basePowerUnit>MVA</pss:basePowerUnit>
   <pss:busList>
   ...
   </pss:busList>
   <pss:branchList>
   ...
   </pss:branchList>
 </pss:baseCase>
</pss:PSSStudyCase>
```

Example - Bus Data

```
<pss:bus>
  <pss:name>Gen Bus-4 1000 Volt</pss:name>
  <pss:id>Bus4</pss:id>
  <pss:baseVoltage>1000</pss:baseVoltage>
  <pss:baseVoltageUnit>VOLT</pss:baseVoltageUnit>
  <pss:loadflowBusData>
    <pss:voltage>
      <pss:voltage>1.05</pss:voltage>
      <pss:unit>PU</pss:unit>
    </pss:voltage>
    <pss:genData>
      <pss:code>PV</pss:code>
      <pss:gen>
    <pss:p>500.0</pss:p>
    <pss:q>0.0</pss:q>
    <pss:unit>MVA</pss:unit>
      </pss:gen>
    </pss:genData>
  </pss:loadflowBusData>
</pss:bus>
```

Example - Branch Data

```
<pss:branch>
  <pss:id>Bus3_to_Bus5_cirId_1</pss:id>
  <pss:fromBus>
    <pss:idRef>Bus3</pss:idRef>
  </pss:fromBus>
  <pss:toBus>
    <pss:idRef>Bus5</pss:idRef>
  </pss:toBus>
  <pss:circuitId>1</pss:circuitId>
  <pss:loadflowBranchData>
    <pss:code>Transformer</pss:code>
    <pss:xformerData>
      <pss:z>
    <pss:r>0.0</pss:r>
    <pss:x>0.03</pss:x>
    <pss:unit>PU</pss:unit>
      </pss:z>
      <pss:fromTurnRatio>1.05</pss:fromTurnRatio>
    </pss:xformerData>
  </pss:loadflowBranchData>
</pss:branch>
```

Conclusions

- We have presented a novel approach based on the XML schema for storing and exchanging power system data.
- We call this approach the Open Data Model.
- It is “open” for two reasons: because it is freely documented and because it can be easily adapted to include any information related to power system analysis.
- The implementation of the ODM schema is currently at an early development stage. Any volunteers?

Thanks for your attention!

Questions?