An architecture for flexible and autonomous network management systems

E. M. Davidson, S. D. J. McArthur, J. R. McDonald, P. C Taylor*

Institute for Energy and Environment, University of Strathclyde
*Durham University
Introduction

- ANM requirements & the AuRA-NMS concept
- The building blocks of AuRA-NMS
  - Hardware
  - Software
- The AuRA-NMS agent-based architecture
- 2 case study networks:
  - 33kV interconnected
  - 11kV radial
- Status of development & future work
AuRA-NMS

Autonomous Regional Active Network Management System

- Project partners include:
  - 7 Universities in the UK
  - 2 Distribution Network Operators in the UK
  - ABB

- Authors’ role - system architecture & control algorithm development
AuRA-NMS

**Autonomous Regional Active Network Management System**

- A fully integrated active network management system:
  - Addresses multiple issues:
    - Power flow management
    - Steady-state voltage control
    - Restoration
  - Coordination across multiple substations
  - Flexible and extensible solution
Example Network

Challenges:
- DG Access
  - Deferral of reinforcement
  - Planning
- Network Performance
  - CML/CI
  - Losses
- Complexity of ANM
  - Flexibility/Extensibility
  - Graceful Degradation
Example Network

Current network automation strategies:

One of 9 such schemes!
AuRA-NMS development

A structured development process:
- Specification of requirements
- Functional specification
- Unit prototypes & testing
  - Power Flow Management;
  - Voltage control; and
  - Restoration
- Integration with AuRA-NMS agent architecture
- Testing through real time simulation
Hardware Building Blocks

- IEC 61850 compliant substation computing equipment
- Existing IEDs, augmented with new IEDs, PLCs and PACs
- Existing/augmented communications infrastructure
Hardware Building Blocks

COM6xx unit provides:
- Substation computing platform
- IEC 61850 gateway services for legacy protocols
Software Building Blocks

- Standards:
  - IEC 61850 data model
  - Common Information Model
  - Foundation for Intelligent Physical Agents
    https://www.fipa.org

- Legacy software components:
  - Off-the-shelf FIPA compliant MAS platform
  - ABB’s Legacy protocol to IEC 61850 translation software
  - Off-the-shelf load flow engine
  - Distribution state estimator (under development by ABB)
Software Building Blocks

- AuRA-NMS agent-based software for:
  - Power flow management
  - Automatic restoration
  - Voltage control
  - Arbitration
Software Building Blocks


Prague, 8-11 June 2009

Network Model: CWPBS Software/PowerFlow Management/CSV/18.0/SEDA/RemoteSite/001_Wilmswick_HighGIS_HighLoad_Initial
Generator Controls: CWPBS Software/PowerFlow Management/CSV/18.0/SEDA/RemoteSite/001_wilmswick_HighGIS_HighLoad_Initial

01/21/09 09:29:26: Overloads detected on the following circuits:

- RHVDC 12 - D926: 17.5 MVA (Rated: 17.5 MVA)

01/21/09 09:29:25: The following measures are being applied:

- LLBWS: Generator can run unconstrained (5.8 MVA)
- LLBWS: Generator can run unconstrained (4.35 MVA)
- DEP Group 2: Generator can run unconstrained (23 MVA)
- DEP Group 3: Generator can run unconstrained (12 MVA)
- DEP Group 1: Generator should be constrained to max output of 11.5 MVA (50.0%)
- MYNR: Generator can run unconstrained (10.3 MVA)
- RMW/BR: Generator can run unconstrained (2.4 MVA)

Time taken to compute solution using CSP: 1.806524867

01/21/09 09:29:31: Overloads no longer detected

01/21/09 09:29:56: Network loading is such that constraints on generation can be removed.

The following measures are being applied:

- LLBWS: Generator can run unconstrained (5.8 MVA)
- LLBWS: Generator can run unconstrained (4.35 MVA)
- DEP Group 2: Generator can run unconstrained (23 MVA)
- DEP Group 3: Generator can run unconstrained (12 MVA)
- DEP Group 1: Generator should be constrained to max output of 11.5 MVA (50.0%)
- MYNR: Generator can run unconstrained (10.3 MVA)
- RMW/BR: Generator can run unconstrained (2.4 MVA)

Time taken to compute solution using CSP: 1.806524867
Software Architecture

OPC Servers (IEC 61850 data model)

- DF
- AMS
- Platform Federator
- PFM Agent
- AR Agent
- Distribution State Estimator
- VC Agent
- Arbitration Agent

Euan Davidson - UK Session 4 Paper 0833
Software Architecture

Power systems control functionality can be distributed across COM6xx Units

Euan Davidson -UK Session 4 Paper 0833
Case Study Network 1

Deployed functionality:
- Power flow management
- Voltage control
- Arbitration service
Case Study Network 2

Deployed functionality:
- Power flow management
- Voltage control
- Automatic restoration
- Arbitration service
Status of Development

- Testing of MAS platform on COM6xx units
- Unit testing of individual approaches using real time simulation:
  - Power flow management
  - Voltage control
  - Restoration
- Most robust approaches to be integrated with the AuRA-NMS architecture