

# The TTC 2017 Outage System Case for Incremental Model Views

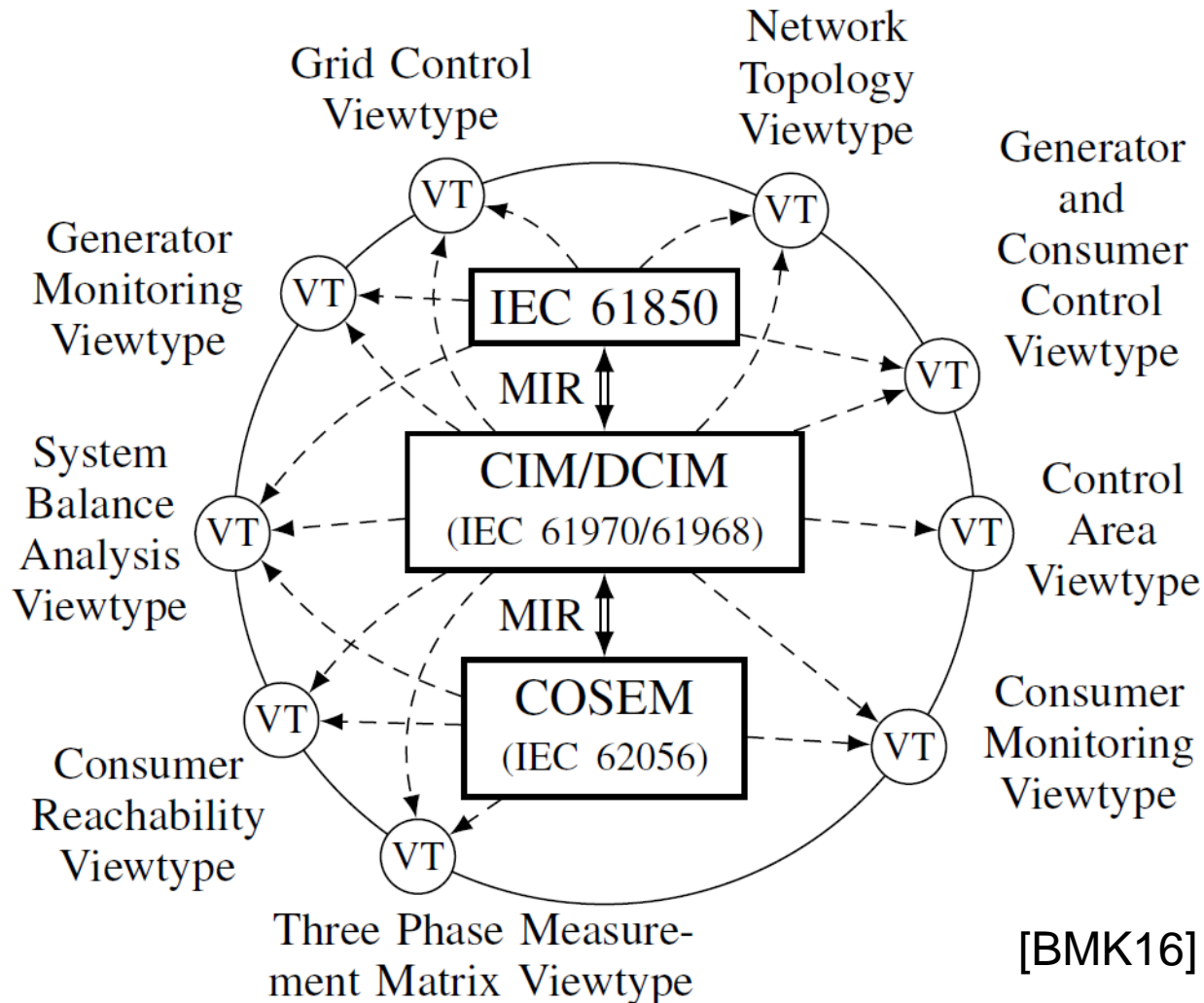
Georg Hinkel

# Multitude of Standards in Smart Grids

- IEC 61970 Common Information Model (CIM)
  - Physical components, measurement of data, control
- IEC 61968 Distributed CIM (DCIM)
  - Extension of IEC 61970 for distribution network
- IEC 61850 Series of standards
  - Interoperability of intelligent electronic devices in substation automation systems
- IEC 62056 Companion Specification for Energy Metering (COSEM)
  - Data exchange for meter reading, tariff and load control

CIM + DCIM  
>20k elements,  
>800 Classes

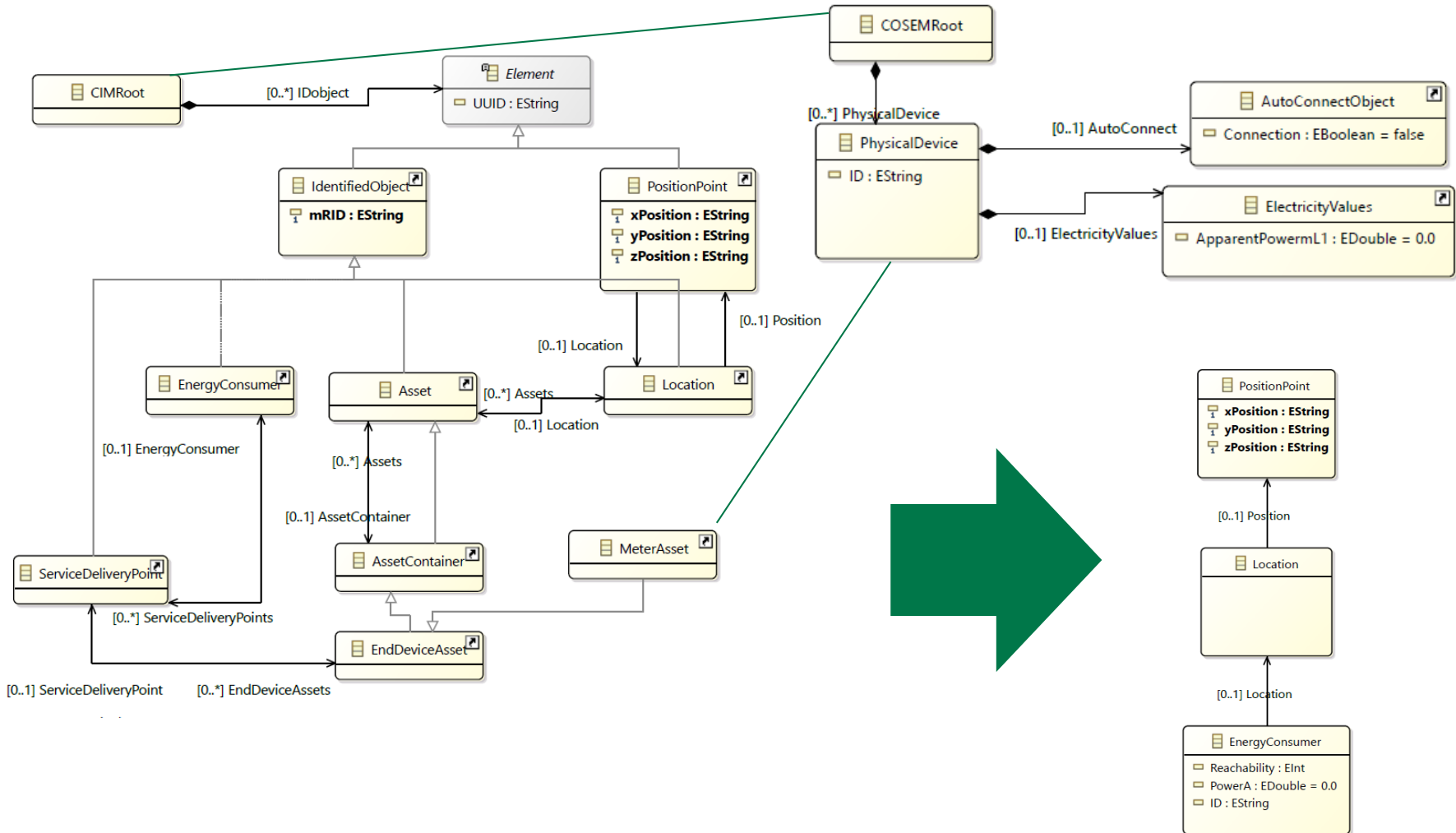
# A model-based Outage Management System



# Tasks

- Create view instances for two of the views in [BMK16], if possible incrementally
  
- OutageDetection task
  - Join CIM and COSEM model to keep an overview of the connection to smart meters
  - View combines the location of a smart meter with its connectivity
  
- OutagePrevention task
  - Detect disturbances of a network by computing indicators of a voltage wave
  - View selects voltage values from a substation and from smart meters
  
- Reference solution in MODELJOIN [BHK+14] available

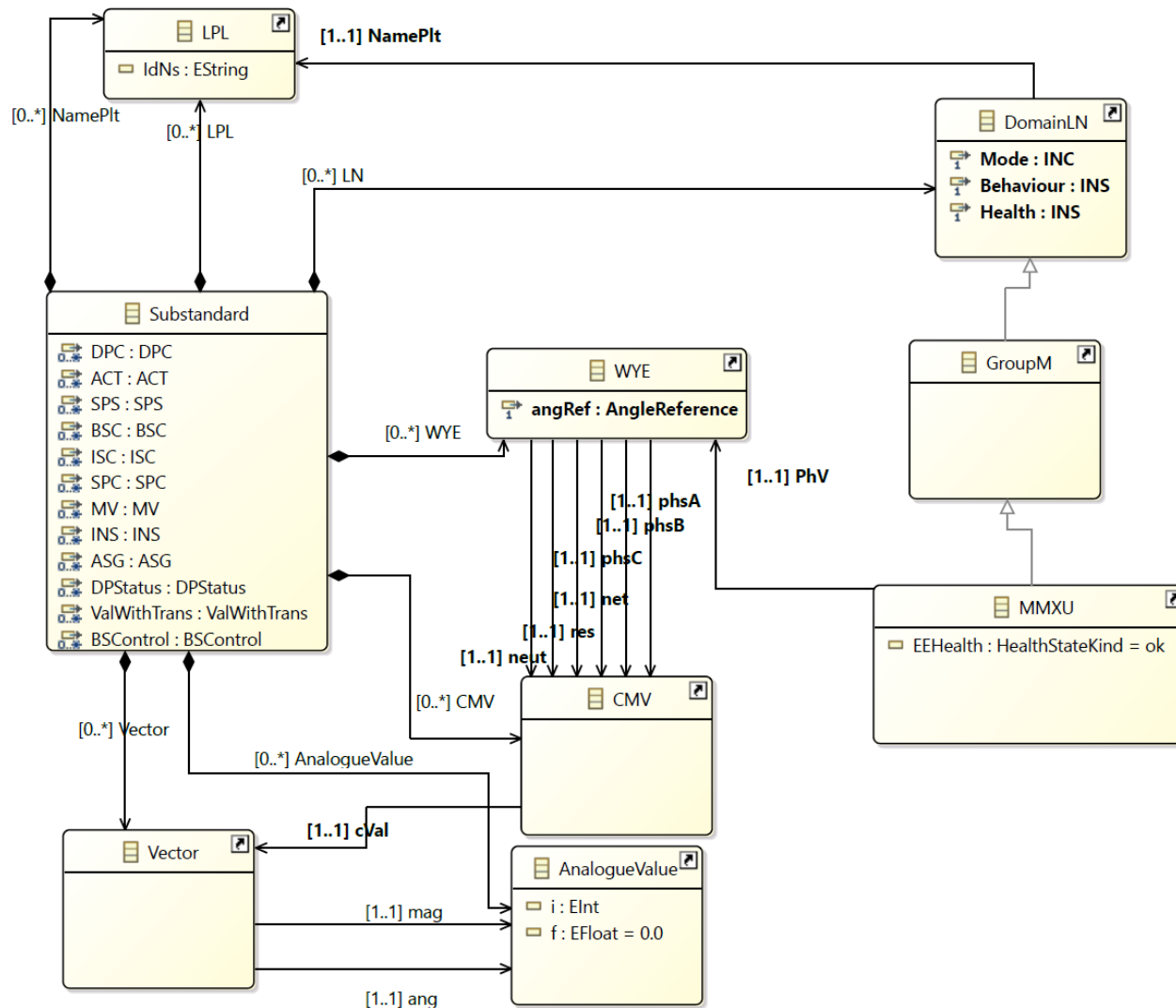
# Outage Detection Task: Metamodel excerpts



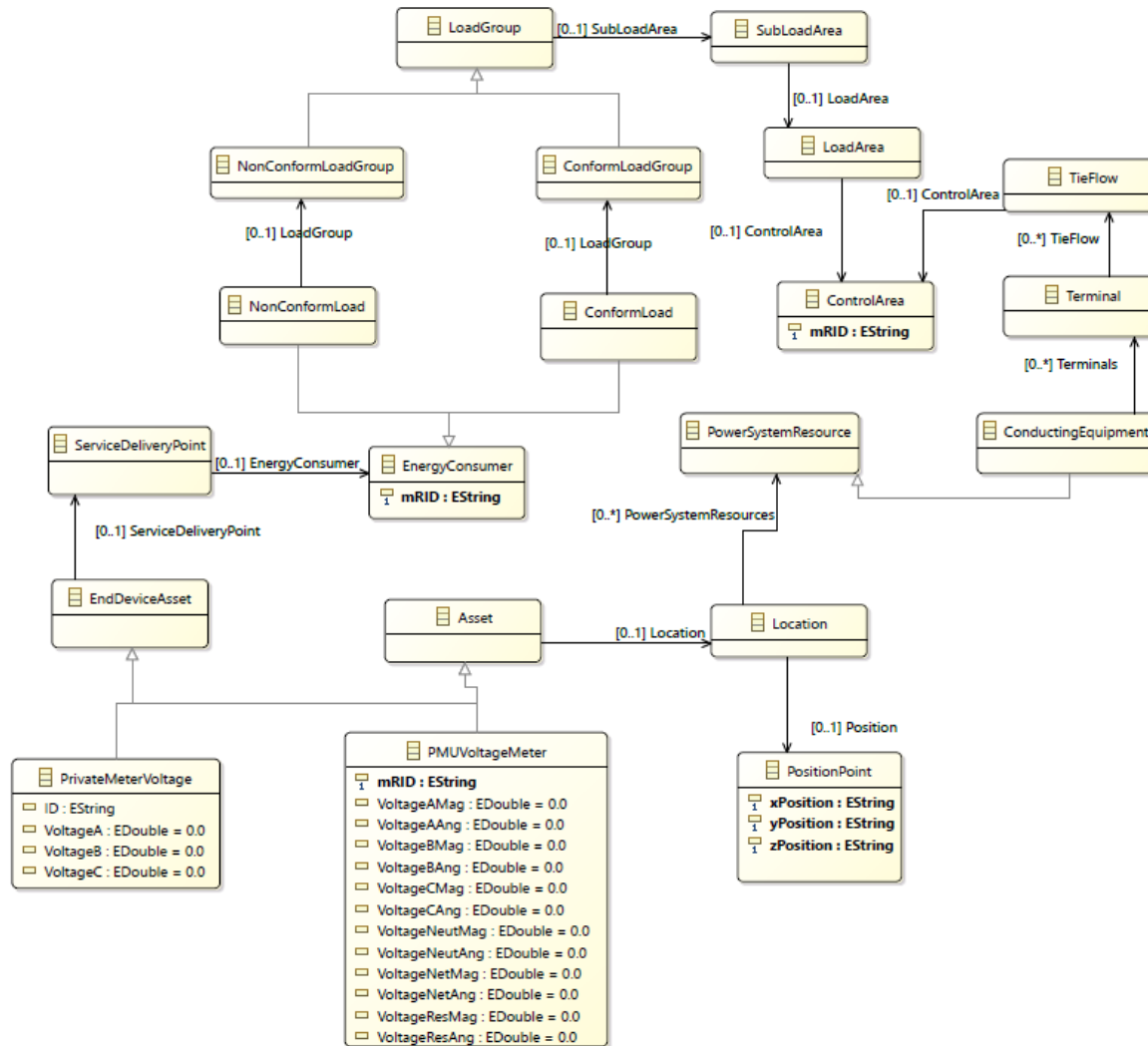
# Outage Detection Task: View

```
1 theta join CIM.IEC61968.Metering.MeterAsset with COSEM.PhysicalDevice where "CIM.IEC61968.Metering.MeterAsset.mRID=COSEM.
   PhysicalDevice.ID" as jointarget.EnergyConsumer {
2   keep calculated attribute "COSEM.PhysicalDevice.AutoConnect.Connection" as EnergyConsumer.Reachability:Integer
3   keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.ApparentPowermL1" as EnergyConsumer.PowerA:Double
4   keep calculated attribute "CIM.IEC61968.Metering.MeterAsset.ServiceDeliveryPoint.EnergyConsumer.mRID" as EnergyConsumer.ID:
   String
5   keep calculated attribute "if_CIM.IEC61968.Metering.MeterAsset.ServiceDeliveryPoint.EnergyConsumer->oclIsKindOf(CIM.IEC61970.
   LoadModel.ConformLoad)_then_CIM.IEC61968.Metering.MeterAsset.ServiceDeliveryPoint.EnergyConsumer.ConformLoadGroup.
   SubLoadArea.LoadArea.ControlArea.mRID_else_CIM.IEC61968.Metering.MeterAsset.ServiceDeliveryPoint.EnergyConsumer.
   NonConformLoadGroup.SubLoadArea.LoadArea.ControlArea.mRID_endif" as Consumer.ControlAreaID:String
6   keep outgoing CIM.IEC61968.Assets.Asset.Location as type jointarget.Location {
7     keep outgoing CIM.IEC61968.Common.Location.Position as type jointarget.PositionPoint {
8       keep attributes CIM.IEC61968.Common.PositionPoint.xPosition,
9       CIM.IEC61968.Common.PositionPoint.yPosition,
10      CIM.IEC61968.Common.PositionPoint.zPosition
11    }
12  }
13 }
```

# Outage Prevention Task: IEC 61850 Metamodel excerpt



# Outage Prevention Task: Target Metamodel





# Outage Prevention Task: View

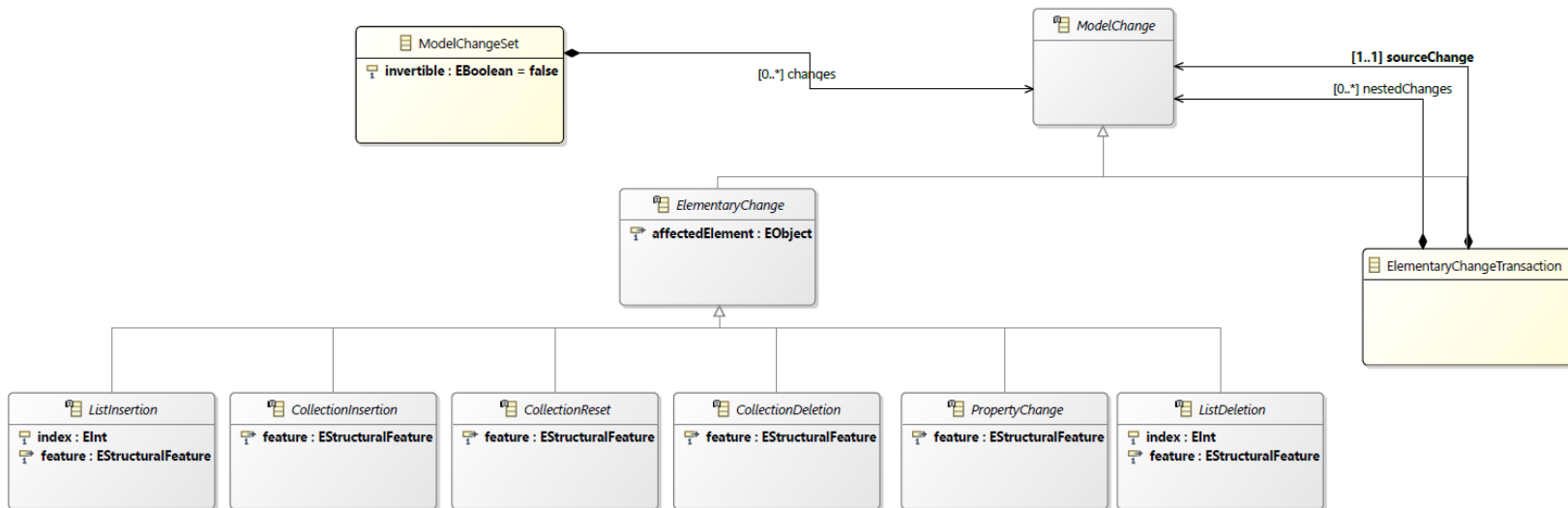
```
1  theta join CIM.IEC61968.Metering.MeterAsset with substationStandard.LNNodes.LNGroupM.MMXU where "CIM.IEC61968.Metering.MeterAsset.
    mRID_=_substationStandard.LNNodes.LNGroupM.MMXU.NamePlt.IdNs" as jointarget.PMUVoltageMeter {
2  keep attributes CIM.IEC61970.Core.IdentifiedObject.mRID
3  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsA.cVal.mag.f" as PMUVoltageMeter.VoltageAMag:Double
4  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsA.cVal.ang.f" as PMUVoltageMeter.VoltageAAng:Double
5  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsB.cVal.mag.f" as PMUVoltageMeter.VoltageBMag:Double
6  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsB.cVal.ang.f" as PMUVoltageMeter.VoltageBAng:Double
7  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsC.cVal.mag.f" as PMUVoltageMeter.VoltageCMag:Double
8  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.phsC.cVal.ang.f" as PMUVoltageMeter.VoltageCAng:Double
9  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.neut.cVal.mag.f" as PMUVoltageMeter.VoltageNeutMag:
    Double
10  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.neut.cVal.ang.f" as PMUVoltageMeter.VoltageNeutAng:
    Double
11  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.net.cVal.mag.f" as PMUVoltageMeter.VoltageNetMag:Double
12  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.net.cVal.ang.f" as PMUVoltageMeter.VoltageNetAng:Double
13  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.res.cVal.mag.f" as PMUVoltageMeter.VoltageResMag:Double
14  keep calculated attribute "substationStandard.LNNodes.LNGroupM.MMXU.PhV.res.cVal.ang.f" as PMUVoltageMeter.VoltageResAng:Double
15  keep supertype CIM.IEC61968.Assets.Asset as type jointarget.Asset {
16  keep outgoing CIM.IEC61968.Assets.Asset.Location as type jointarget.Location {
17  keep outgoing CIM.IEC61968.Common.Location.Position as type jointarget.PositionPoint {
18  keep attributes CIM.IEC61968.Common.PositionPoint.xPosition,
19  CIM.IEC61968.Common.PositionPoint.yPosition,
20  CIM.IEC61968.Common.PositionPoint.zPosition
21  }
22  keep outgoing CIM.IEC61968.Common.Location.PowerSystemResources as type jointarget.PowerSystemResource {
23  keep subtype CIM.IEC61970.Core.ConductingEquipment as type jointarget.ConductingEquipment {
24  keep outgoing CIM.IEC61970.Core.ConductingEquipment.Terminals as type jointarget.Terminal {
25  keep outgoing CIM.IEC61970.Core.Terminal.TieFlow as type jointarget.TieFlow {
26  keep outgoing CIM.IEC61970.ControlArea.TieFlow.ControlArea as type jointarget.ControlArea {
27  keep attributes CIM.IEC61970.Core.IdentifiedObject.mRID
28  }
29  }
30  }
31  }
32  }
33  }
34  }
35  }
36
37  theta join CIM.IEC61968.Metering.MeterAsset with COSEM.PhysicalDevice where "CIM.IEC61968.Metering.MeterAsset.mRID_=_COSEM.
    PhysicalDevice.ID" as jointarget.PrivateMeterVoltage {
38  keep attributes COSEM.PhysicalDevice.ID
39  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageL1" as PrivateMeterVoltage.VoltageA:Double
40  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageL2" as PrivateMeterVoltage.VoltageB:Double
41  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageL3" as PrivateMeterVoltage.VoltageC:Double
42  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageN" as PrivateMeterVoltage.VoltageN:Double
43  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageU" as PrivateMeterVoltage.VoltageU:Double
44  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageV" as PrivateMeterVoltage.VoltageV:Double
45  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageW" as PrivateMeterVoltage.VoltageW:Double
46  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageX" as PrivateMeterVoltage.VoltageX:Double
47  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageY" as PrivateMeterVoltage.VoltageY:Double
48  keep calculated attribute "COSEM.PhysicalDevice.ElectricityValues.VoltageZ" as PrivateMeterVoltage.VoltageZ:Double
49  }
50  }
```

# Benchmark Framework and Setup

- Benchmark divided in four phases
  - Initialization: Initialize framework, load metamodels, etc.
  - Load: Load initial models into memory
  - Initial: Transform initial view
  - Update (x20): Apply an update sequence
  
- Models available as XMI either for each state or as change models

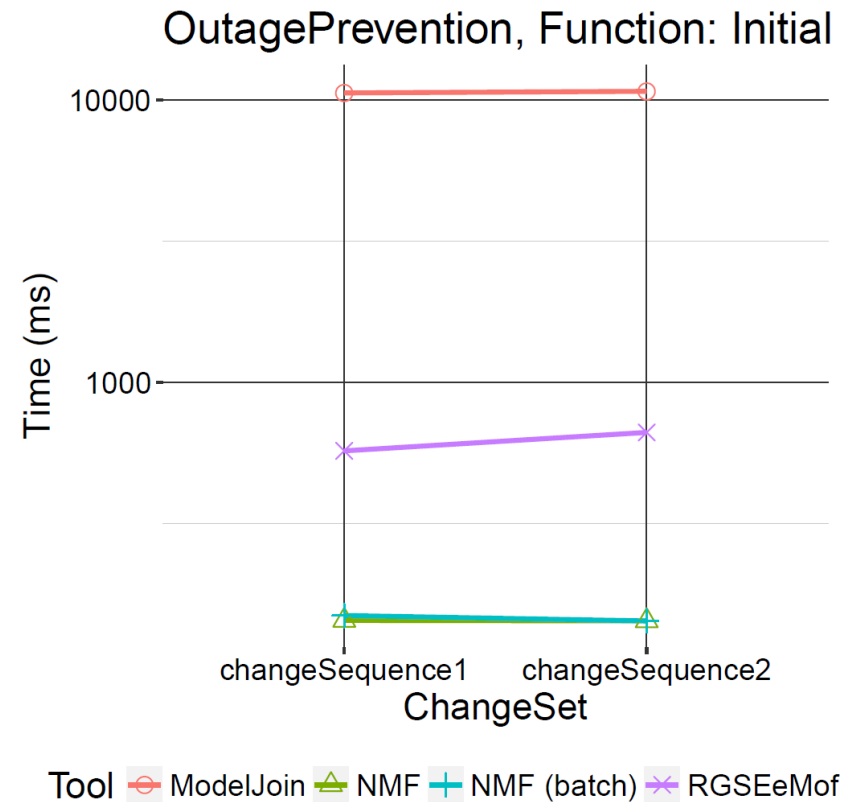
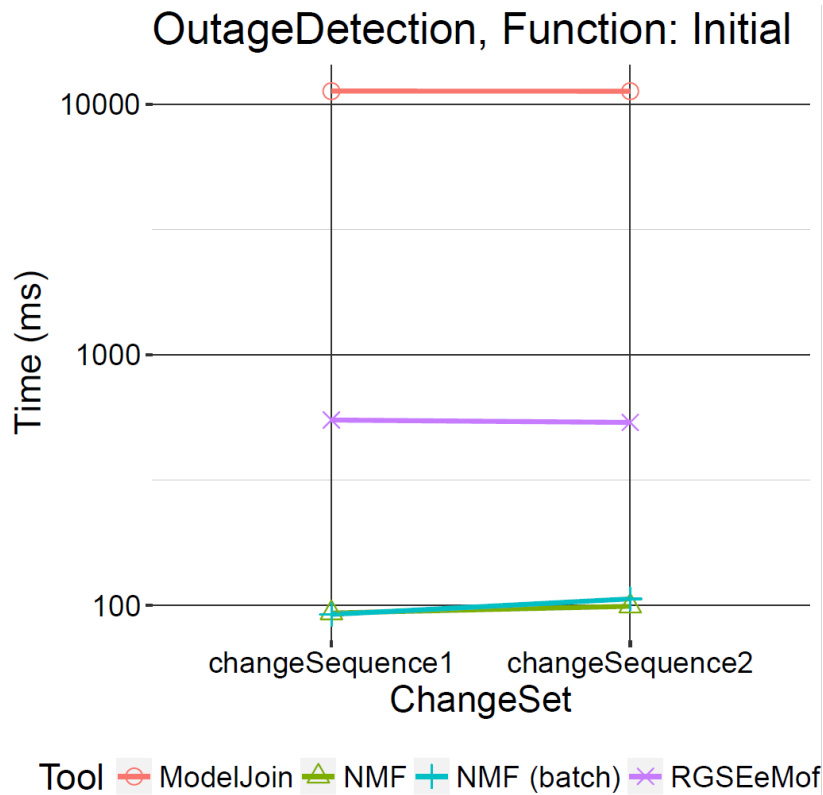
# Change Metamodel

- Ecore metamodel of NMF Change descriptions available along with case resources

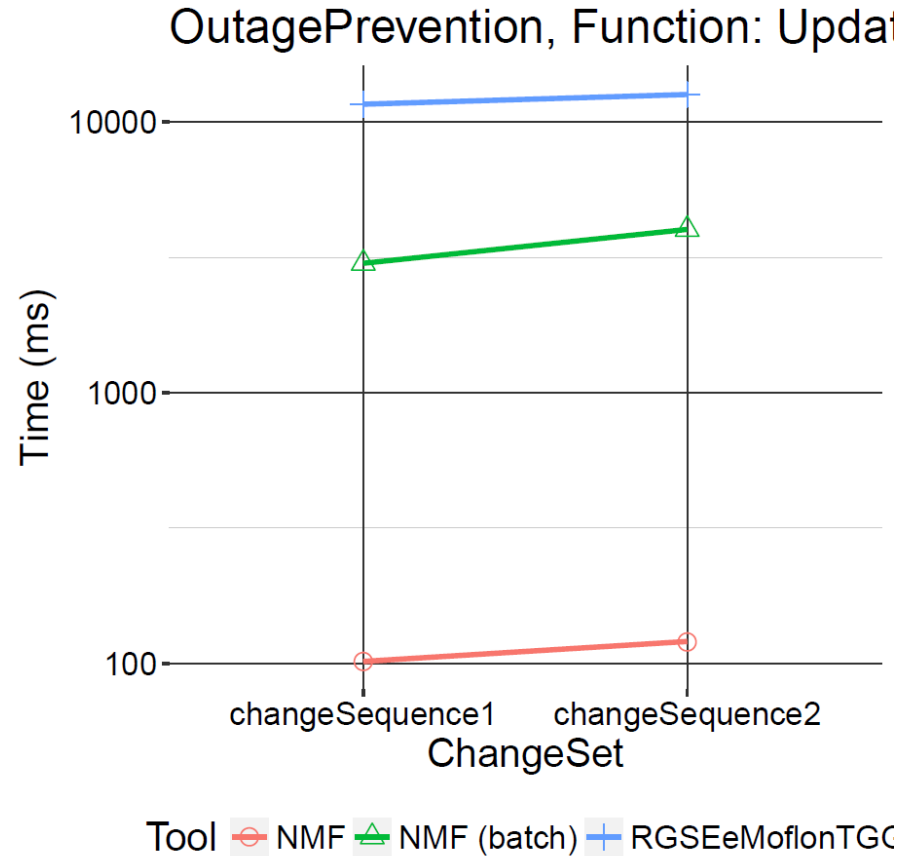
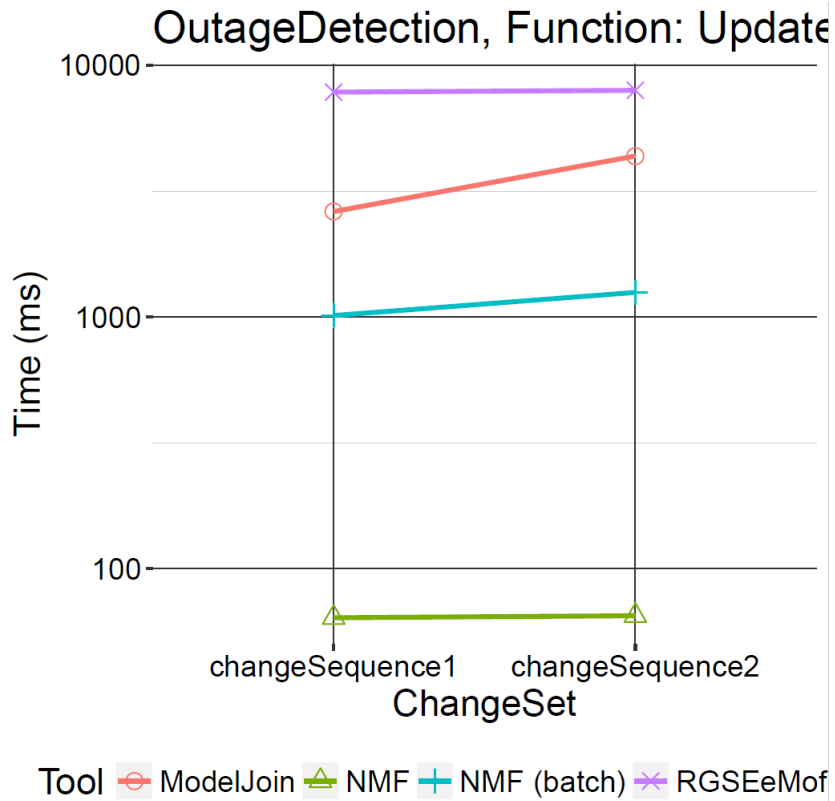


- Can be transformed into change representations of the respective modeling tool

# Results Batch



# Results Incremental



# Conclusion

- Combine Multiple Models in (incremental) model views

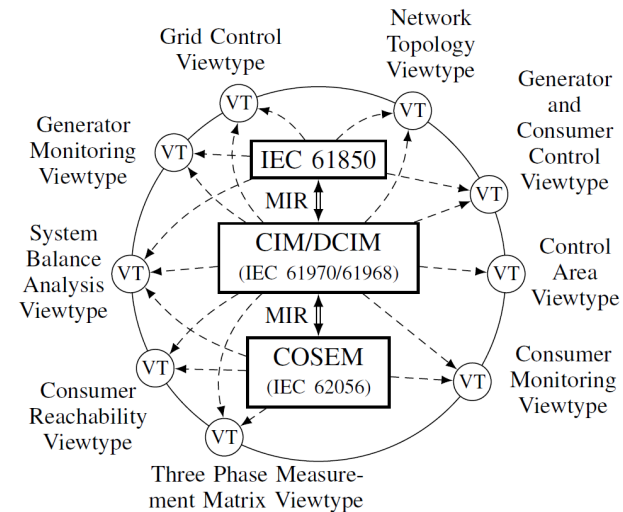
- IEC 61968/61970
- IEC 61850
- IEC 62056

- Application in the Smart Grid domain

- Detect Outages
- Prevent (predict) Outages

- Propagate changes or recreate view model from scratch

- Changes available in NMF Change format



[hinkel@fzi.de](mailto:hinkel@fzi.de)

**THANK YOU FOR YOUR ATTENTION**

# References

- [Mit15] V. Mittelbach, “Model-driven Consistency Preservation in Cyber-Physical Systems,” Master’s thesis, Karlsruhe Institute of Technology (KIT), Germany.
- [BMK16] E. Burger, V. Mittelbach, and A. Koziolk, “Model-driven consistency preservation in cyber-physical systems,” in Models@run.time co-located with MODELS 2016, CEUR Workshop Proceedings, 2016.
- [IEC11] IEC 61970 energy management system application program interface (ems-api) - part 301 common information model (cim) base, 2011
- [IEC15] IEC 61850 communication networks and systems for power utility automation 2015
- [DUA14] D. U. Association, “Excerpt from companion specification for energy metering cosem interface classes and obis identification system,” 2014
- [BHK+14] E. Burger, J. Henß, M. Küster, S. Kruse, and L. Happe, “View-Based Model-Driven Software Development with ModelJoin,” Software & Systems Modeling, vol. 15, no. 2, pp. 472–496, 2014.