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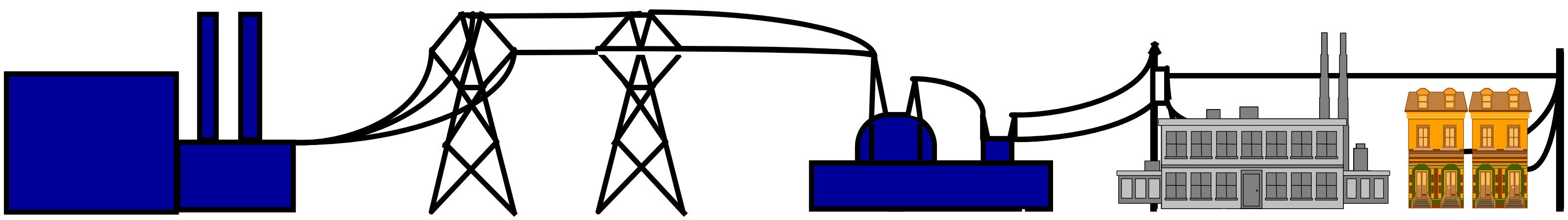
Semantic Modeling with the CIM

28 February 2012

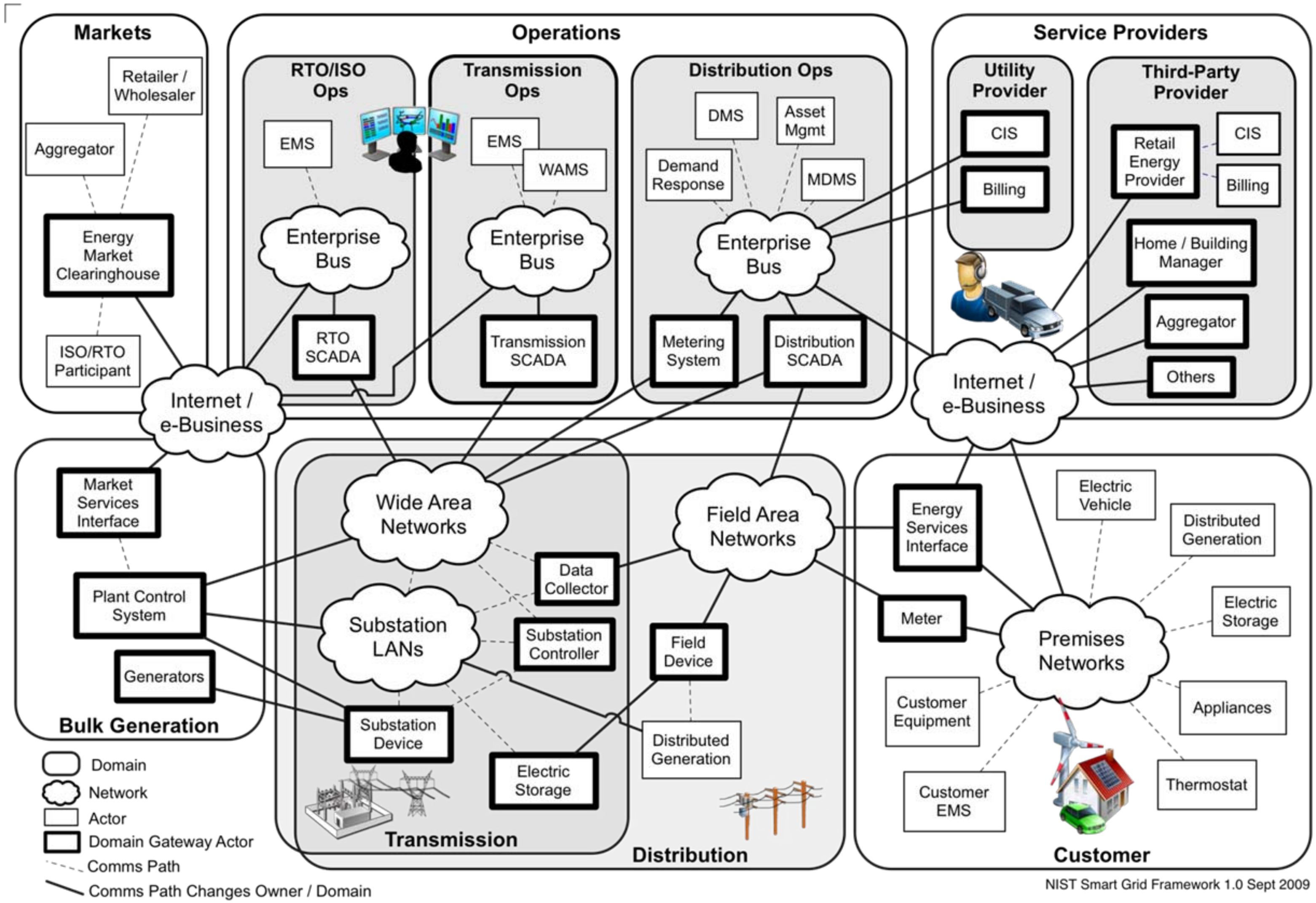
Terry Saxton



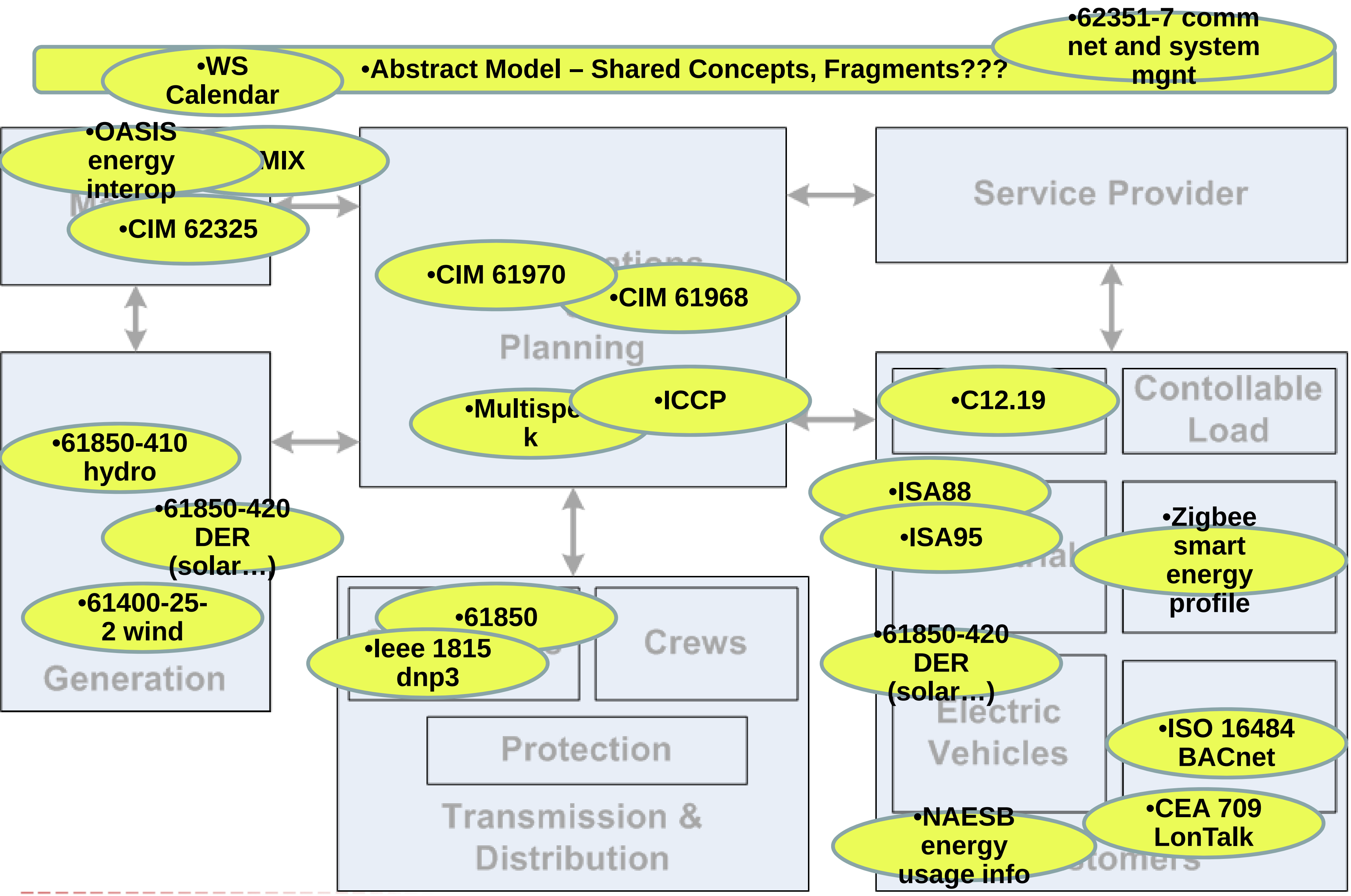
Presentation Contents

- NIST Smart Grid Roadmap and CIM
- CIM as a semantic model
- Genius and uniqueness of CIM standards
- Business drivers for use of CIM
- Home of CIM Standards – IEC TC57
- Three layer architectural framework for CIM standards
- CIM as a Canonical Data Model
- Harmonization vs. Unification

Smart Grid Conceptual Model – Diving Deeper



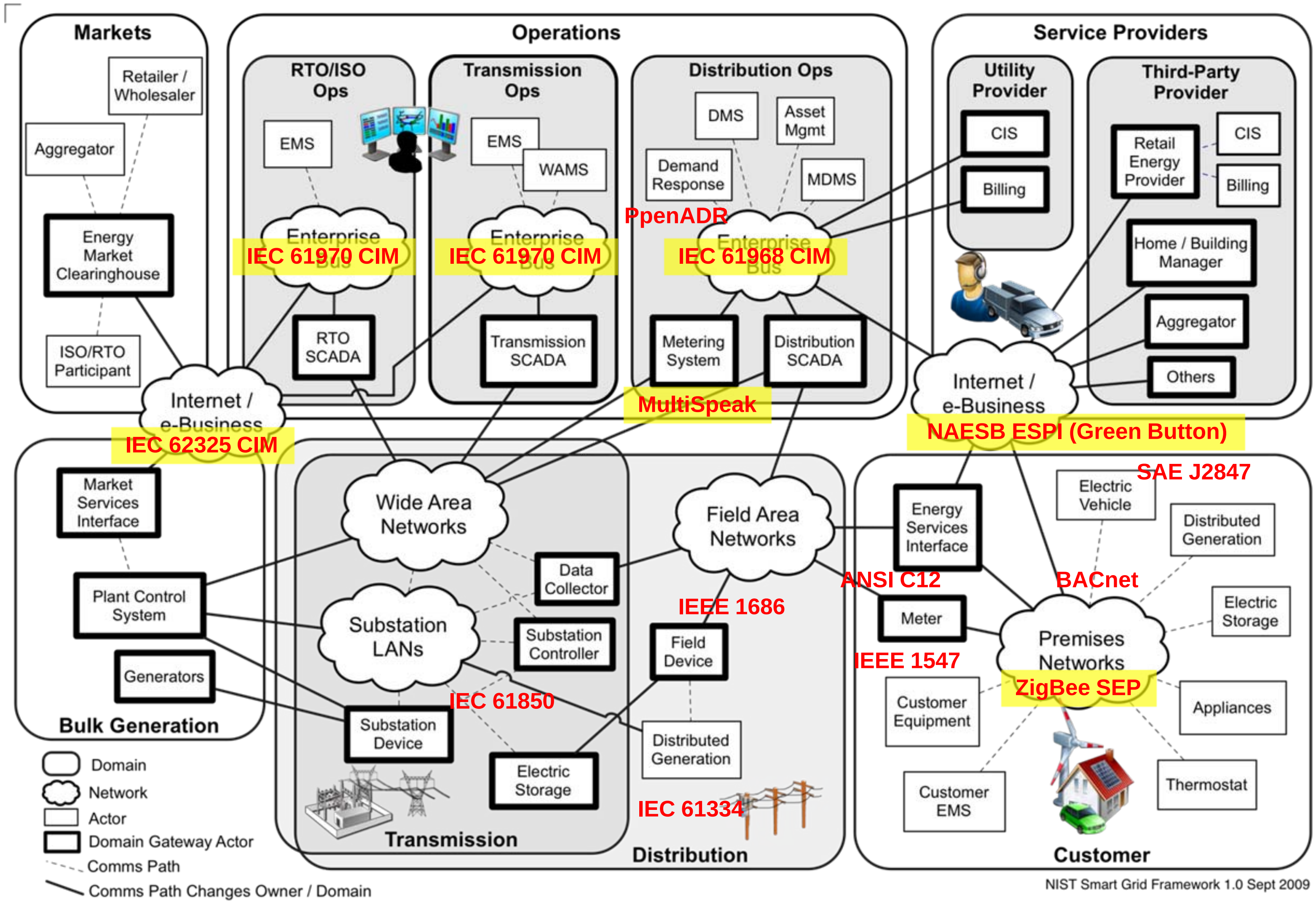
Draft Semantic Mapping



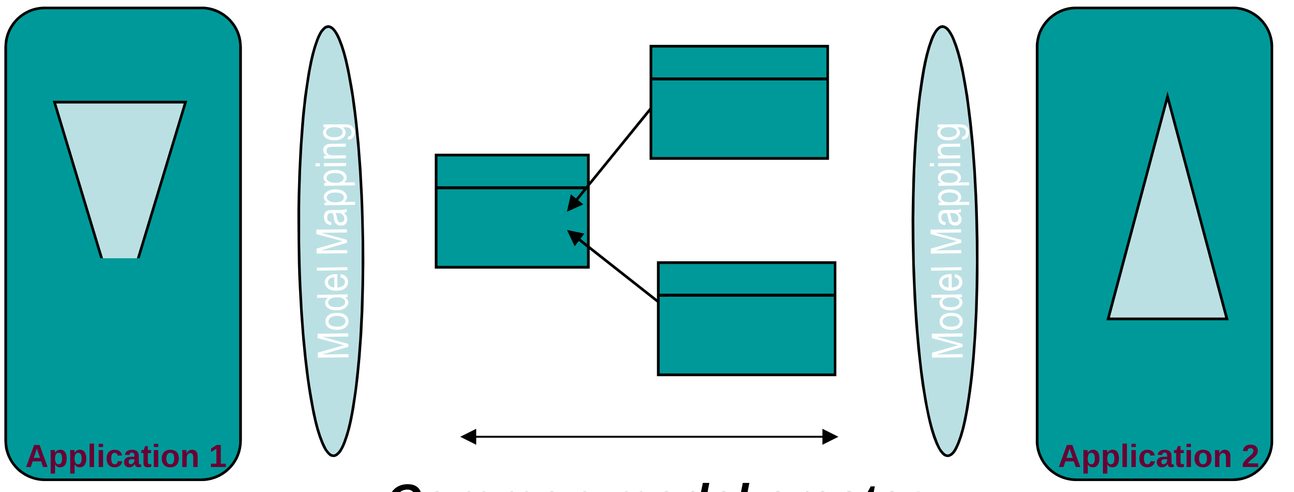
NIST SG Interoperability Vision

- NIST identified as one of five cross-cutting, overarching issues the needed for a common semantic model
  - One key area – "… the integration of utility Transmission and Distribution field operations with Information Technology and Back Office Systems and ultimately with Customer Premise Systems."
    - IEC 61968/61970 CIM has already addressed this are and has approved standards in place and in use world-wide
  - Overall solution
    - "NIST should work with IEC TC57, NEMA, ASHRAE SPC 135, and OASIS to devise a common semantic model. The objective will be to ***unify*** the models of CIM (IEC61970, IEC61968), MultiSpeak and IEC 61850 including correspondences with ANSI C12.19 and ASHRAE 135 to form a common representation of information models constructed by these standards efforts for the Smart Grid"

Smart Grid Conceptual Model – Diving Deeper



Application of Information Model



Common model creates understanding

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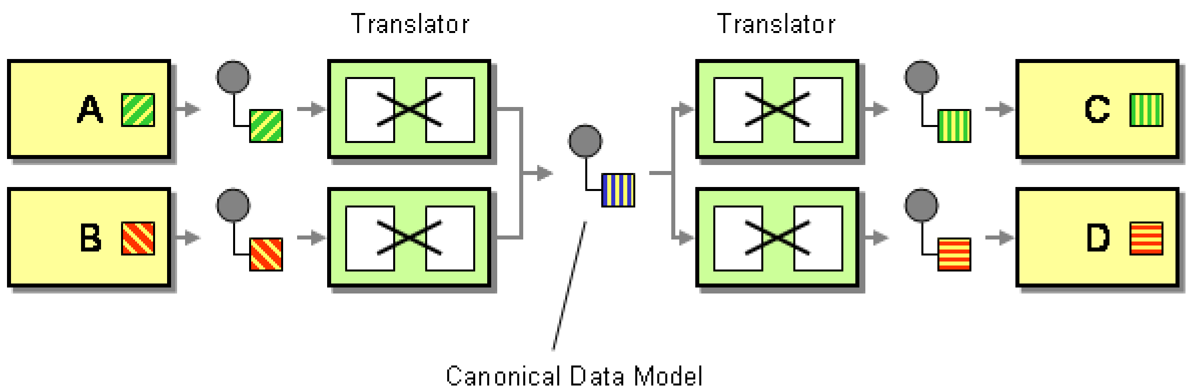
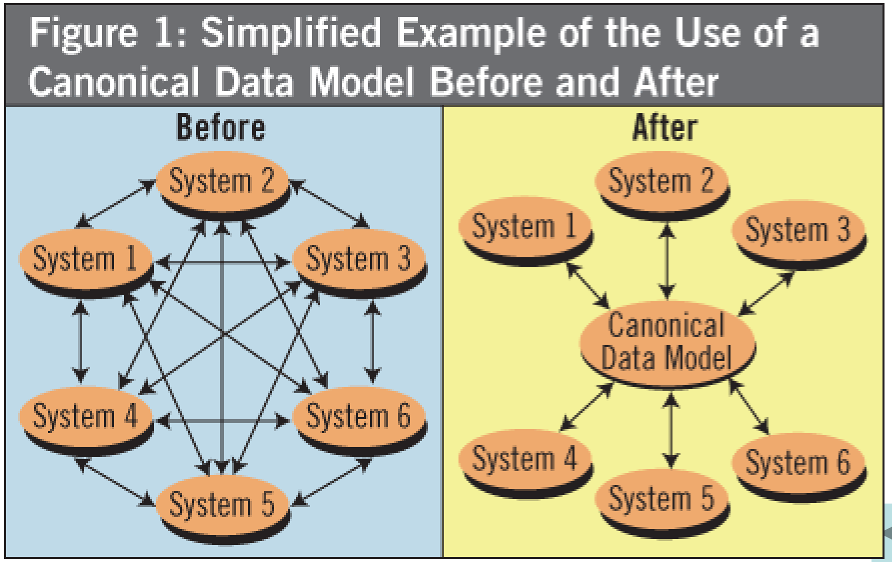
Role of CIM in Smart Grid Architecture

- CIM standards aim to simplify integration of components and expand options for supply of components by standardizing information exchanges
  - Reduce complexity with clear consistent semantic modeling across the enterprise
  - Data sources: achieve a clear picture of data mastership in the enterprise
  - Data consumers: make ‘data of record’ available on demand to qualified users
- CIM employs a *canonical data model* (CDM) strategy for standardizing interfaces in the power system operations and planning domain.

What is a Canonical Data Model?





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How the CIM is Applied to Specific Information Exchanges

- The CIM CDM (also referred to simply as the “Information Model”) is partitioned into sub-domains by IEC WGs
  - These groups work hard to maintain a *unified* semantic model over the whole domain
- The interfaces defined under CIM are defined by Profiles.
  - A profile specifies the information structure of exchanged information by creating contextual semantic models.
    - Contextual semantic models are a subset of the CIM CDM (i.e., they inherit their structure from the CIM CDM)
    - Contextual semantic models could contain information not modeled in the CIM CDM.
      - This is not current CIM practice for standard interfaces (refer to Enterprise Semantic Model discussion)
  - There is typically a family of related interfaces defined within a profile
  - Products implement support for profiles in the form of CIM/XML import/export software or ESB run-time adapters
  - Testing occurs against profiles
  - “CIM compliance” is defined against profiles – otherwise the term is meaningless
- Do not expect CIM CDM to contain every type of information contained in system data bases (e.g., transformer assets)
  - If its not needed in an information exchange at a CIM interface, don’t expect it to be in the model
  - Don’t expect that CIM is a good database schema
  - Don’t expect CIM to make a good class design for your application

How Are CIM Standards Used?

- Unlike most standards we use
  - Ex: ICCP/TASE.2 Communication Protocol standard
  - Fixed functionality, very ***stable***, easy to test ***compliance***, but ***inflexible***
- CIM standards can be strictly applied and tested for compliance
  - Ex: CIM/XML Power system model exchange
  - Product interfaces can be developed and tested for compliance
  - Subject of several EPRI-sponsored interoperability tests for specific interface definition

CIM Layered Architecture
Example: Power Flow Network Model Exchange

•Information and Semantic Models

•Conforms to
IEC 61970-301 CIM

•CIM UML

- **Information Model**
- Defines all concepts needed for exchange of operational load flow models
  - Reused parts
  - New extensions

•Context

•Conforms to
IEC 61970-452, 453, 456, others
Model Exchange Profile

•Power System Model Profile Group

- **Contextual layer restricts information model**
- Specifies which part of CIM is used for static/dynamic model exchange
- Mandatory and optional
- Restrictions
- But cannot add to information model

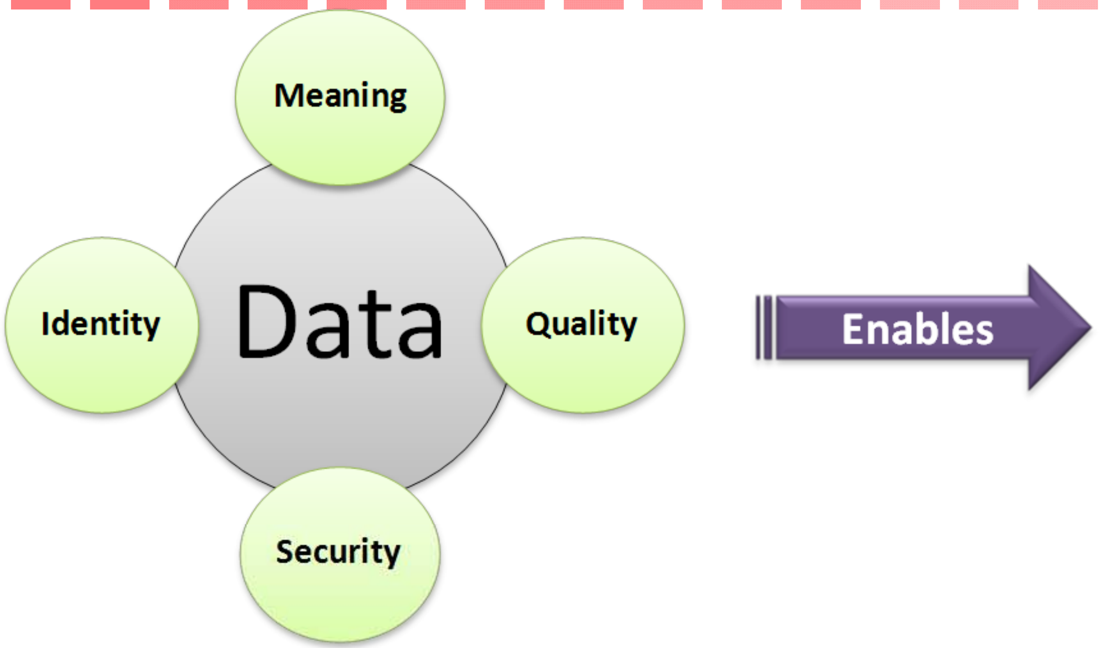
•Message Syntax

•Conforms to
IEC 61970-501 and -552
CIM XML Model Exchange Format

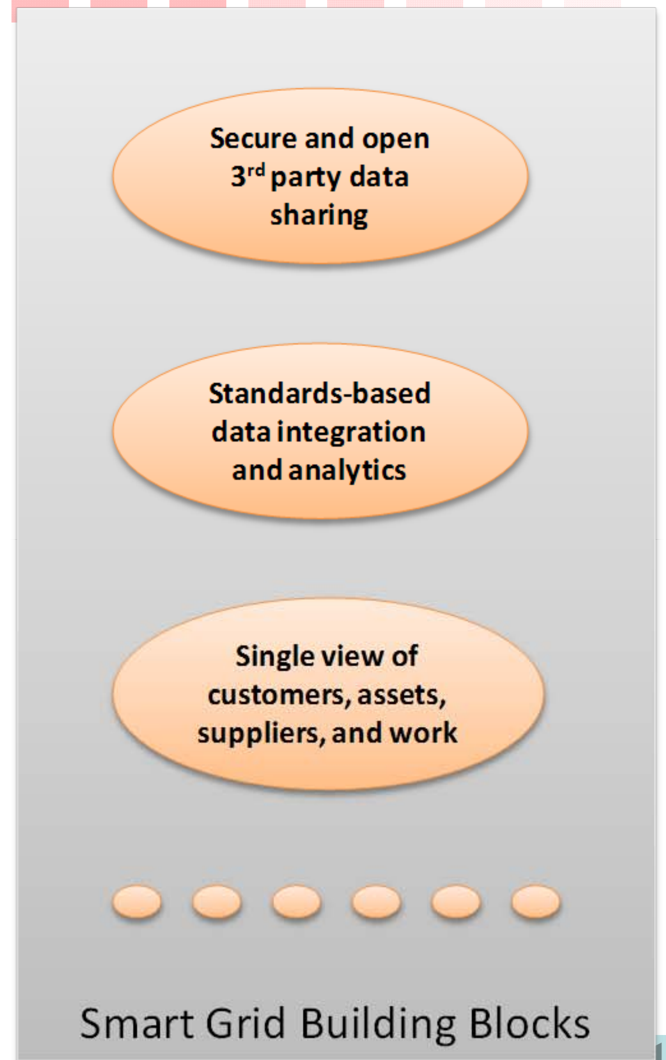
•CIM/RDF Schema

- **File syntax**
- Can re-label elements
- Change associations to define single structure for message payloads
- Mappings to various technologies can be defined
-

Smart Data is Key to Enabling Adaptive Smart Grid Systems



Only when the data is enriched with consistent meaning, identity, quality and security can it be used to support the future Smart Grid needs.

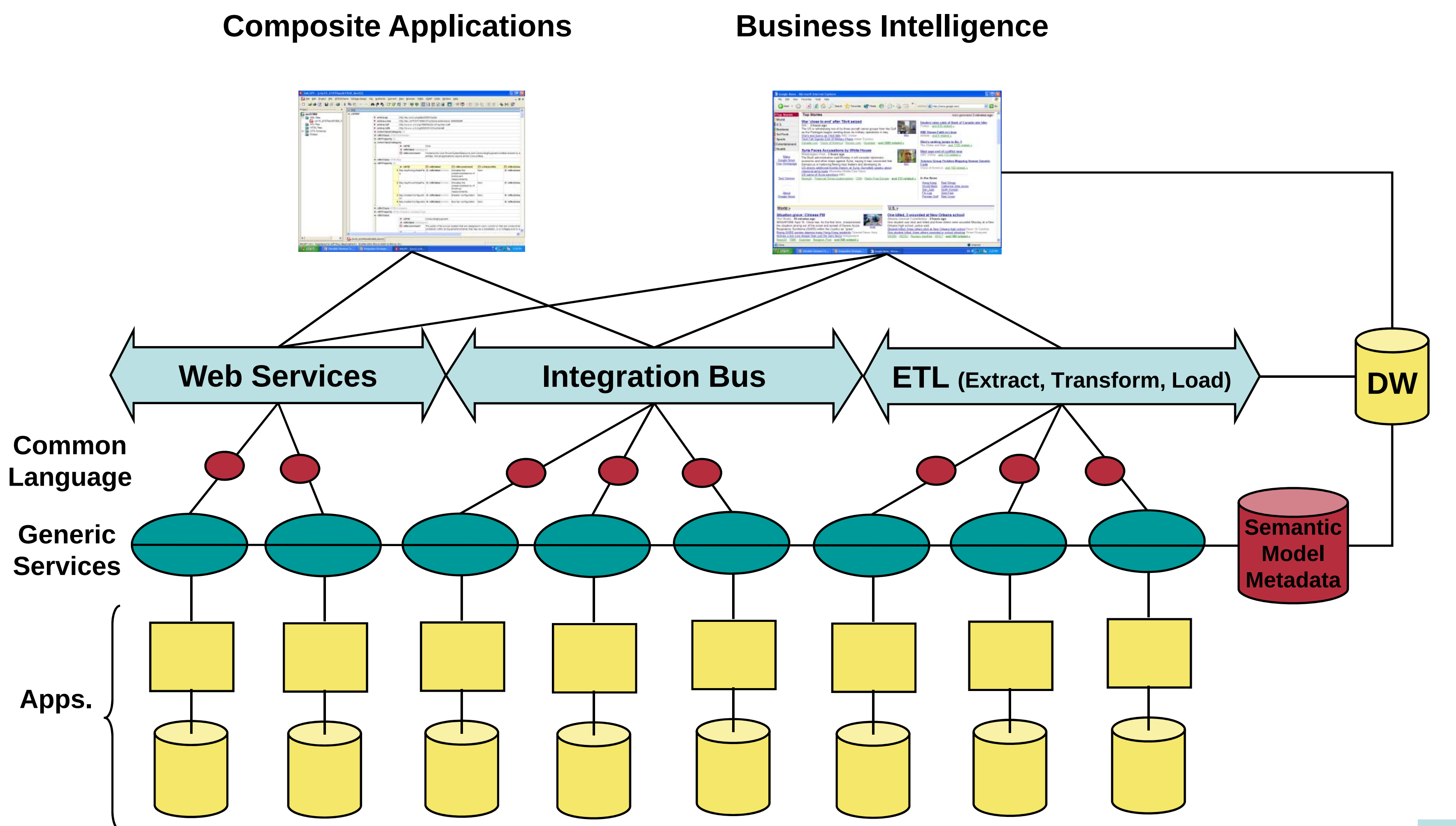


Using A Semantic Model To Simplify & Scale Up The Mapping Process

- What is a Semantic Model?
  - The key ingredients that make up a semantic model are a vocabulary of basic terms, a precise specification of what those terms mean and how they relate to each other.
- How is it used?
  - Before making mappings, a model (or an ontology) of a given business domain is defined.
  - The model is expressed in a knowledge representation language and it contains business concepts, relationships between them and a set of rules.
  - By organizing knowledge in a discrete layer for use by information systems, semantic models enable communication between computer systems in a way that is independent of the individual system technologies, information architectures and applications.
  - Compared to one-to-one mappings, mapping data sources to a common semantic model offer a much more scaleable and maintainable way to manage and integrate enterprise data.

[source: TopQuadrant Technology Briefing, July 2003]

The CIM Provides a Semantic Layer in an Enterprise Architecture



Where CIM is Accepted/Proposed Standard

- Transmission/Distribution Operations and Planning (61970)
  - Power System Network Model management and exchange for RTOs, ISOs, and TOs
- System Integration for Distribution Management (61968)
  - Market Operations, EMS, DMS, OMS, Distribution SCADA, GIS, WMS, Mobile Workforce Management, Asset Management
  - Support for various architectures
- Market Operations Communications (62325)
  - European and North American market
- Smart Grid Enablement (61968)
  - Advanced Metering Infrastructure (AMI)
  - Meter Head End, MDMS, CIS, OMS)
- Consumer Engagement (61968)
  - Peripheral Area Network monitoring and control
  - HAN, Consumer Data Access and Integration (Green Button)

Let's Backup A Bit to Understand Why CIM is Different from Most Other Standards

- How did CIM standards get to this place of prominence in NIST SG Roadmap

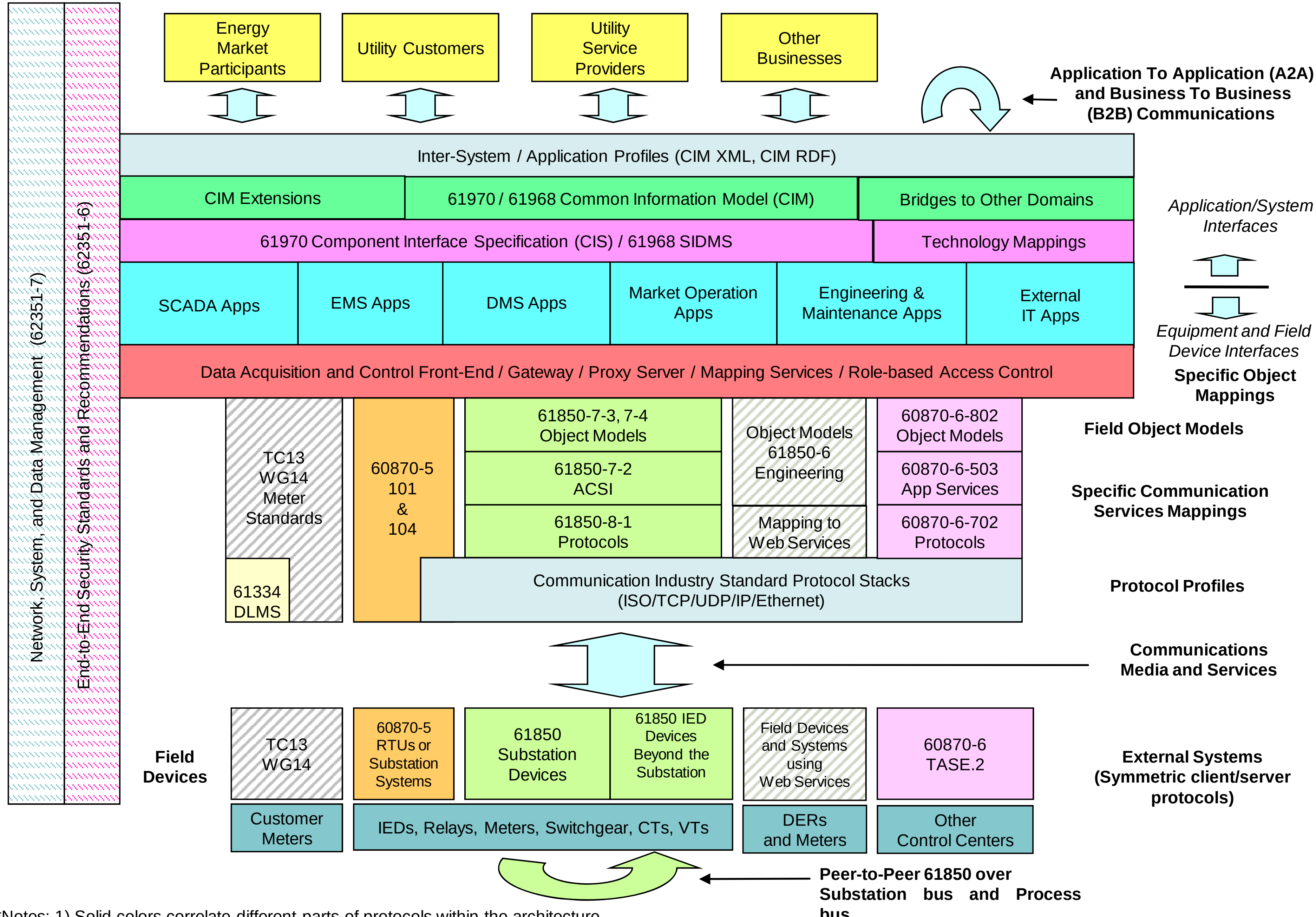
Where it All Started (or at least one version)

- Need for common business terminology for exchanging information between ISOs.
  - Each ISO had their own terms and definitions
  - Approach was to build a new dictionary of terms
  - Process defined for accepting new item into vocabulary
  - No model of real world – just dictionary of terms
  - No software tools for managing dictionary
  - Did not address how this vocabulary could be used for actual serialized exchanges of information between ISOs
  - No way for vendors to implement software
  - No recognized standards that could be applied elsewhere
    - Limited to ISO info exchange – so no market
  - No recognized formats for exchange except CSV files using FTP

Genius of CIM

- Has information exchange with reference to a power system model in view
  - No more detail than needed for information exchange
  - Organized so message payloads can be generated directly from UML
  - Avoids overlap with other standards and ways of organizing data internally for application use
- Used to manage energy at all levels of use, from generation to transmission to distribution to consumption
  - Single model behind all these
- From meta data for standard profiles to ESM that can be tailored
  - Tools available
- Only true international standard applied world-wide being considered by NIST – all others (almost) are North American, with similar but different for Europe and Asia

IEC TC57 - Reference Architecture for Power System Information Exchange



*Notes: 1) Solid colors correlate different parts of protocols within the architecture.
2) Non-solid patterns represent areas that are future work, or work in progress, or related work provided by another IEC TC.

Where CIM is Accepted Standard for System Integration

- Utility Operations
- Work and Asset Management
  - GIS, WMS, Mobile Workforce Management, Asset Management, and Strategic Asset Management Analytics
- Smart Grid Enablement
  - AMI (Meter Head End, MDMS, CIS, OMS, others)
  - Meter Data Analytics
- Consumer Engagement
  - HAN, Consumer Data Access and Integration (Green Button), and DR and Load Control
- Other ???

How Are CIM Standards Used?

- Unlike most standards we use
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How Are CIM Standards Used?

- Unlike most standards that we are used to
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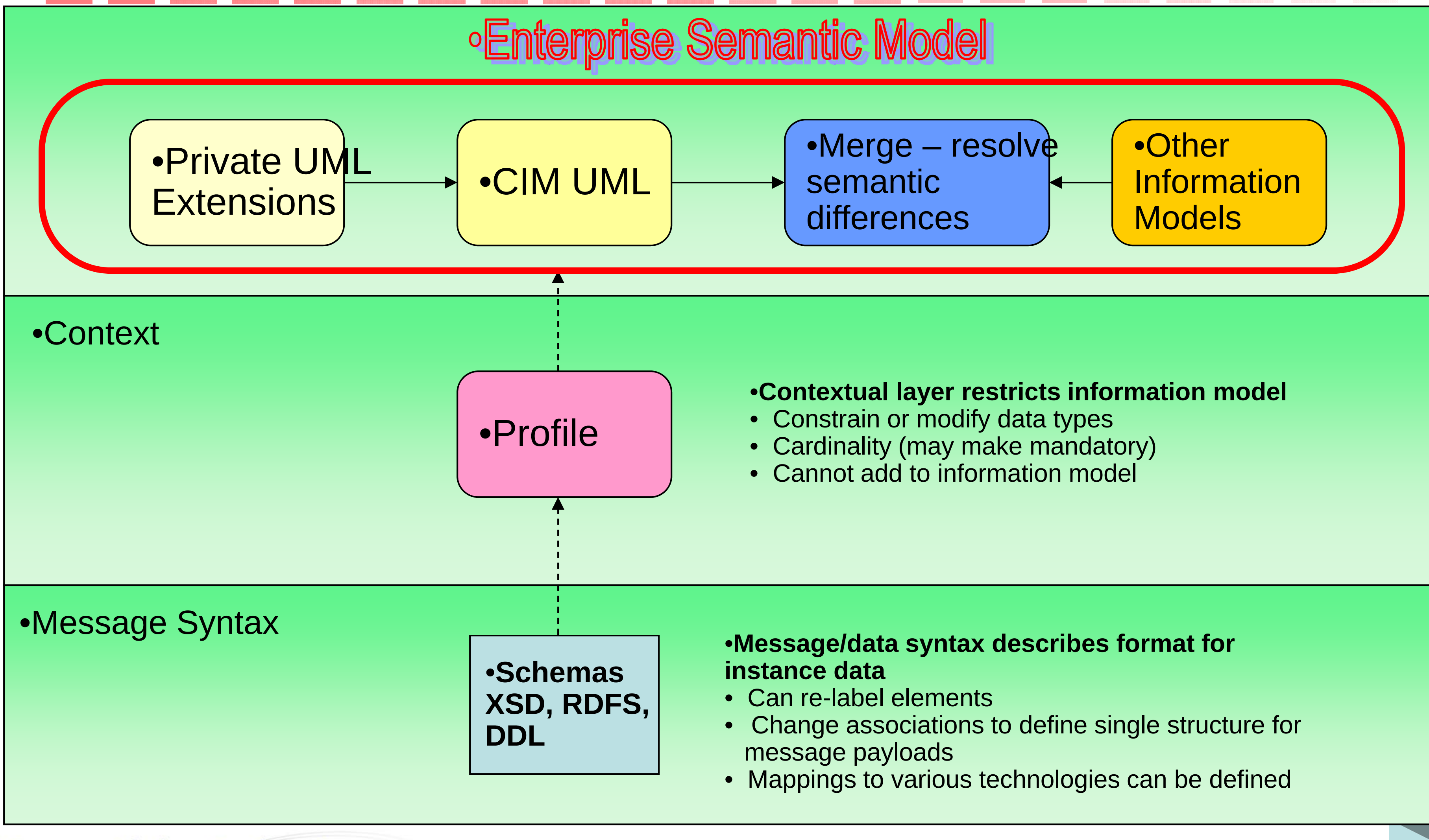
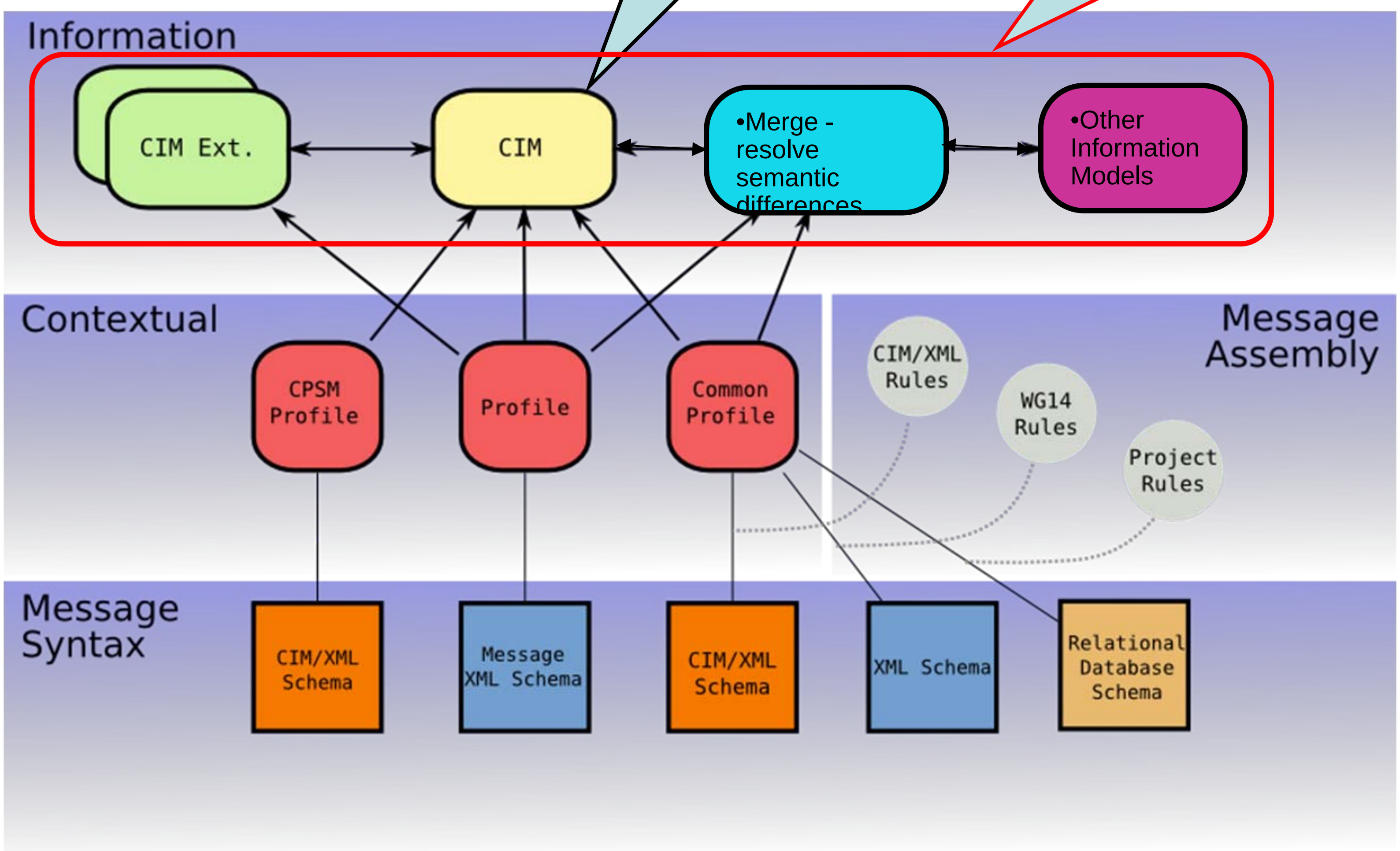
- CIM standards can be strictly applied and tested for compliance
  - Ex: CIM/XML Power system model exchange
  - Product interfaces can be developed and tested for compliance
  - Subject of several EPRI-sponsored interoperability tests for specific interface definition
- CIM can also be used as a starter kit
  - Basis for an Enterprise Semantic Model (ESM) which includes other models/semantics from other sources
  - Ex: Sempra Information Model (SIM)
  - Interfaces are usually project-defined, so no standard tests
  - System interfaces are managed and tested for each project

Enterprise Semantic Models – CIM + Other Industry Standards

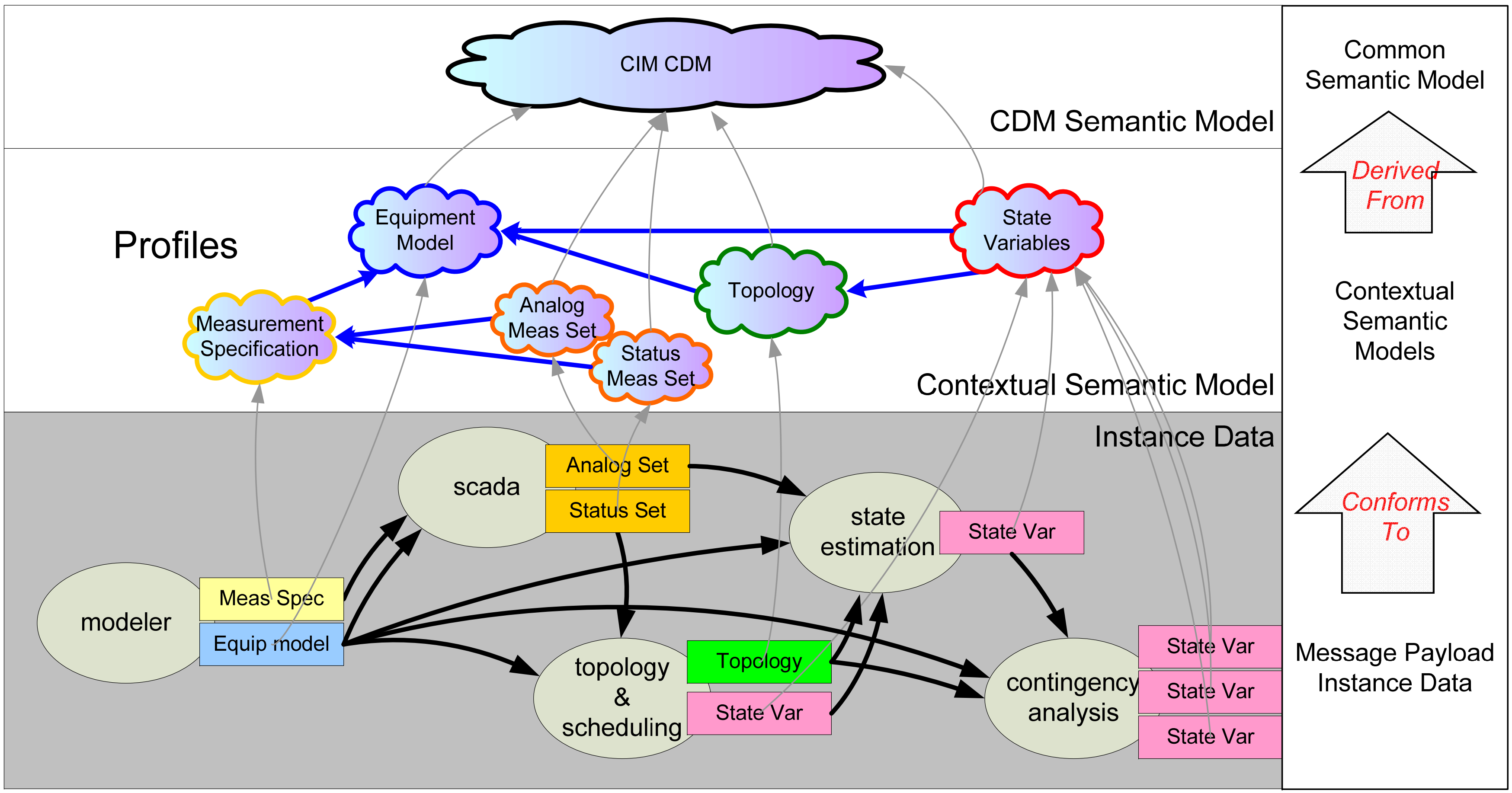


Overview of CIM Standards Architecture

- Pure CIM Canonical Data Model
- Enterprise Semantic Model (ESM) based on CIM



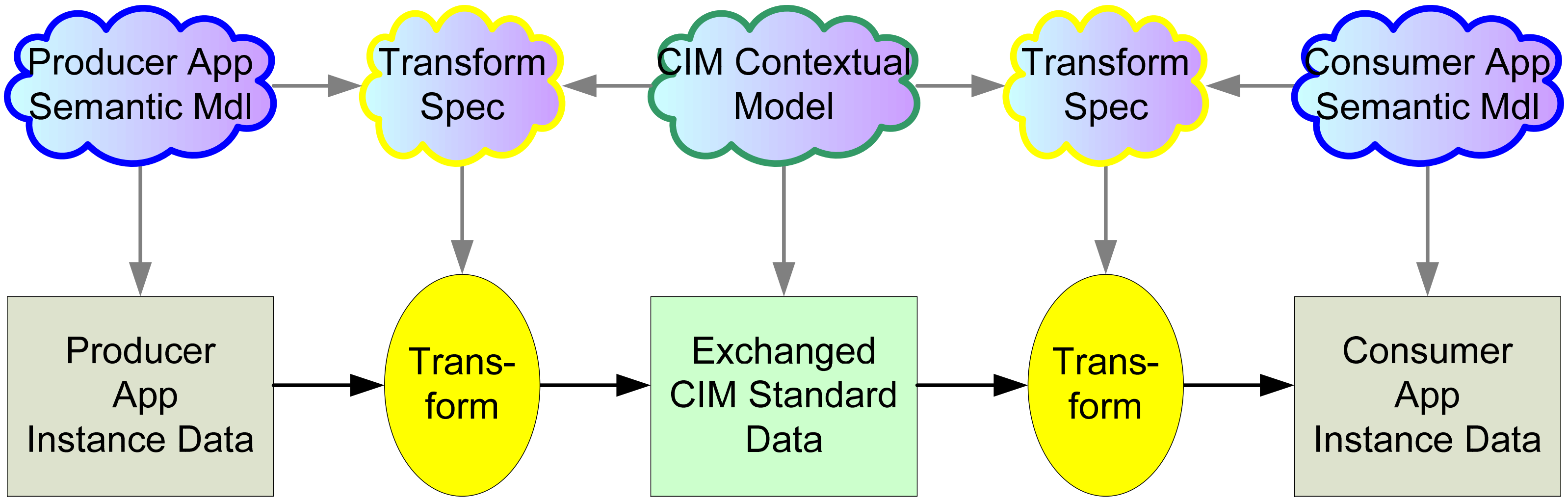
How CIM is Used to Define Standard EMS Application Interfaces



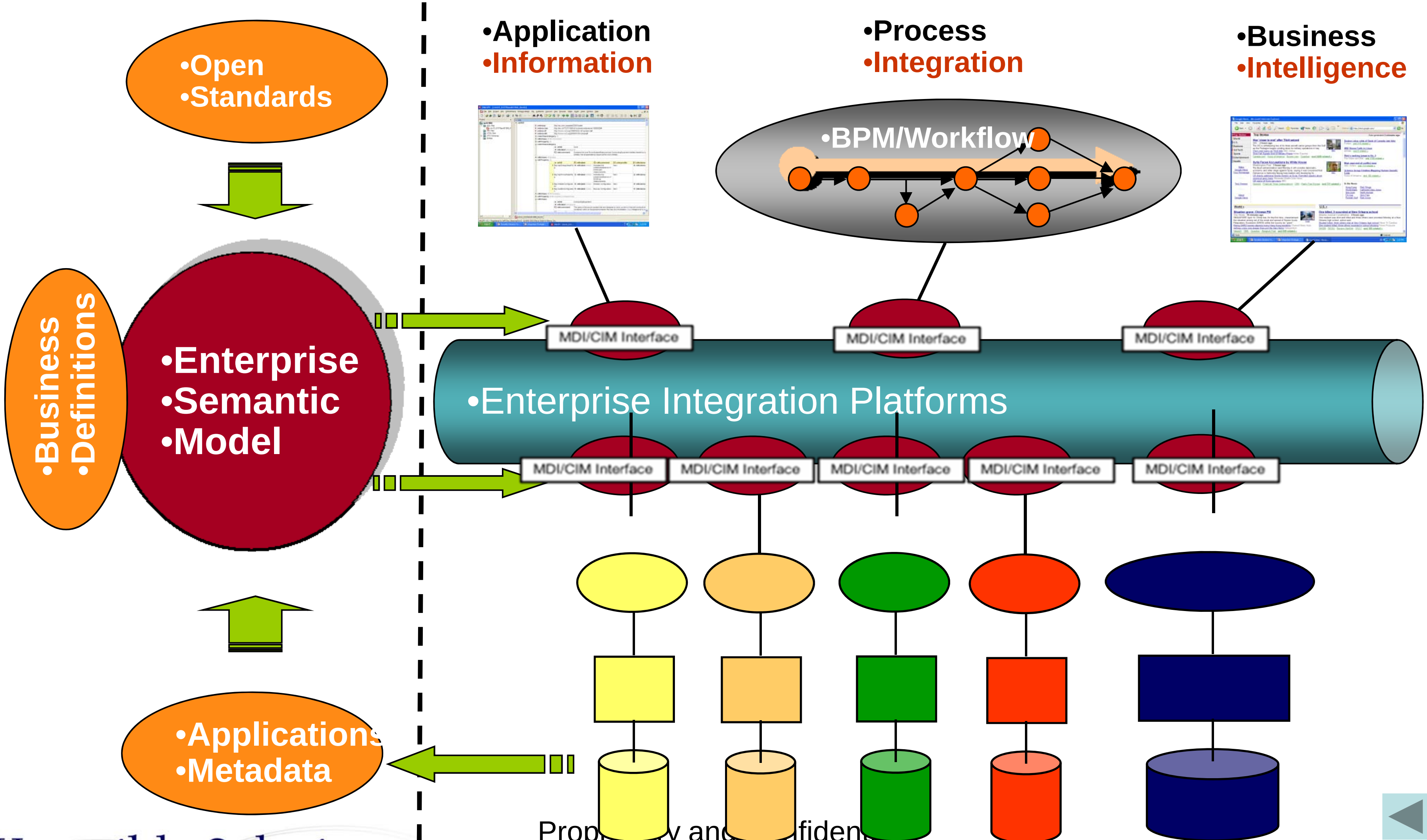
Transformations Connect Local Semantics to Standard Profile Semantics Derived from CDM

Transform issues

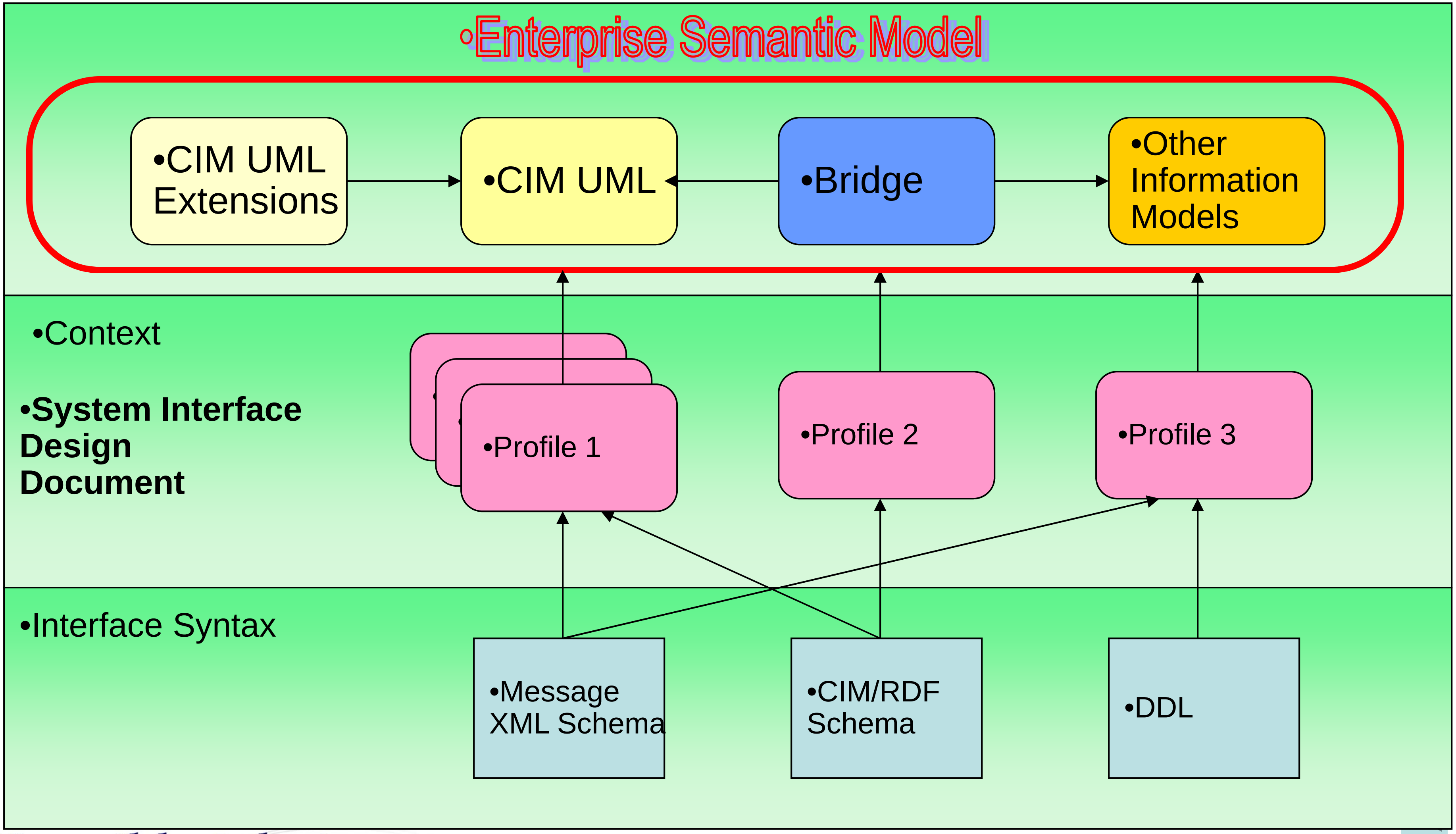
- How to capture Transform Specification
  - Requires mapping with spreadsheet or mapping tool like Progress DXSI
- Where to transform
  - May be import/export software intended for file exchange with other utilties
  - May be run time adapters on an ESB
- Clarity
- Simple, low cost implementation
- Maintainability
- Performance



Role of Enterprise Semantic Model



Let's Apply to a Utility Project - Interface Architecture



CIM Evolution

- CIM is designed to achieve consistent, high quality models across a large domain
  - This mission requires that CIM is able to change as new interfaces are added
  - It is not possible to preserve semantic quality if changes are restricted to additions
  - At the global CDM level, change is embraced as long as it makes a significant contribution to semantic quality
- Stability may be addressed as appropriate at profile levels
  - Profiles are where the investment is made
  - Each profile is derived from a version of the CIM CDM, *but not necessarily the same version*
  - Changes to CIM do not necessarily require that the profile be updated
  - Participants can determine when to update their profile
- About Versioning…
  - CIM CDM and contextual models will change
  - Profiles also change but not in lockstep with the CDM
  - Where there are multiple consumers or producers for a profile, it probably is not practical to synchronize upgrades

Using CIM as an Enterprise Semantic Model (ESM)

- An enterprise integration strategy based on CIM is a good idea, but...
  - Recognize that interoperability standards are driving CIM
  - Priority issues for standardization are not going to be exactly the same as for your enterprise ESM
    - You will need to manage a different version
    - Standard CIM will change – and you won't always appreciate the changes
  - If you do not periodically synchronize with the standard, you will inevitably drift away
    - This re-sync must be planned for and budgeted
- Recommended practice
  - Set up an enterprise information architecture group to define your EIM governance policies
  - Set up an ESM management platform with design-time tools to incorporate needed additions/changes to the CIM reference model as you build out your ESM and create ESM Modeler role
  - Manage transformation implementations
    - This is where a lot of life-cycle cost is centered

Some definitions…

- ***Semantics*** refers to the meaning of a set of information.
- A ***semantic model*** is a structured description of the semantics of a set of information, using some information modeling language (e.g. UML).
  - A semantic model contains 'metadata'.
  - Many different semantic models are possible for the same semantics, even within one modeling language.
  - Semantic modeling only represents information content – it does not include formatting/encoding (syntactical) specifications.
- A ***semantic transformation*** is a procedure for converting a given semantic from one semantic model representation to another.
  - This is to be distinguished from a syntactic transformation that would convert a set of information governed by one semantic model from one format to another.

A ***canonical data model*** (CDM) is a semantic model chosen as a *unifying* model that will govern a collection of data specifications.

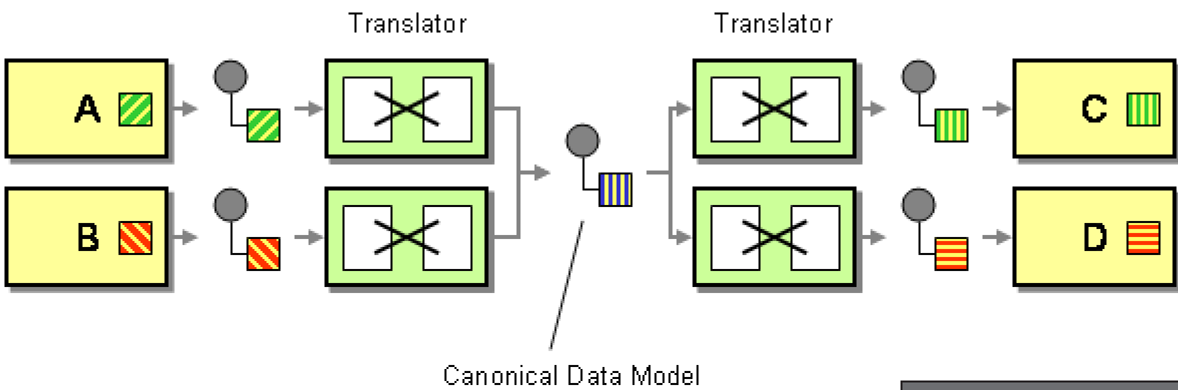
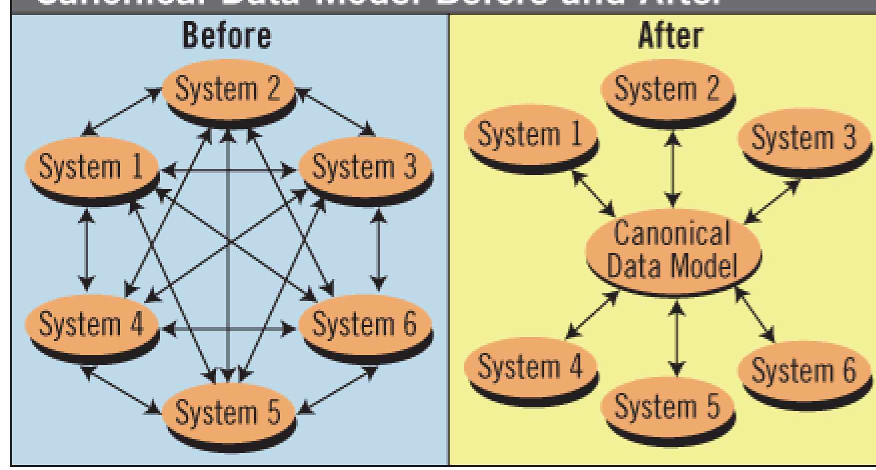
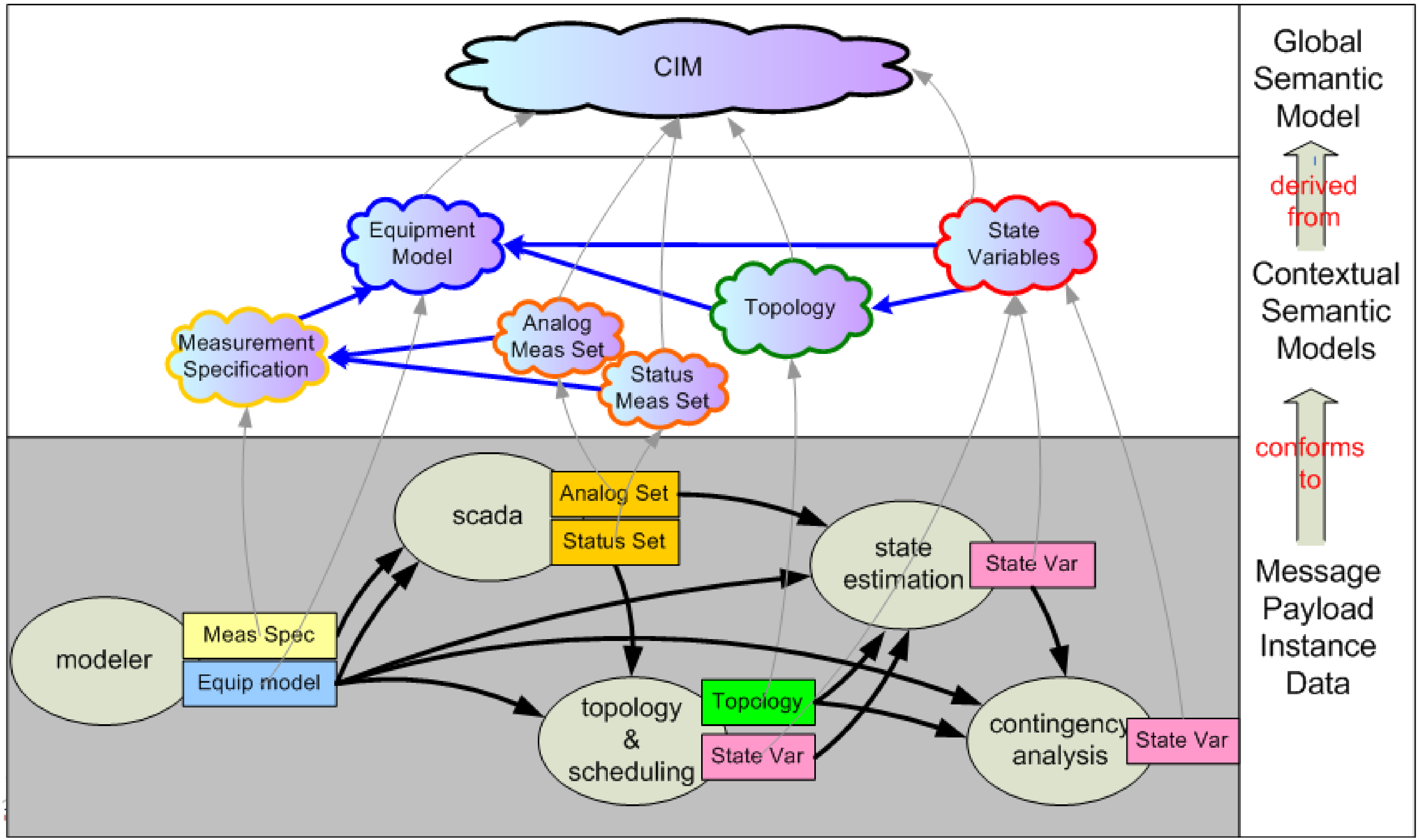


Figure 1: Simplified Example of the Use of a Canonical Data Model Before and After



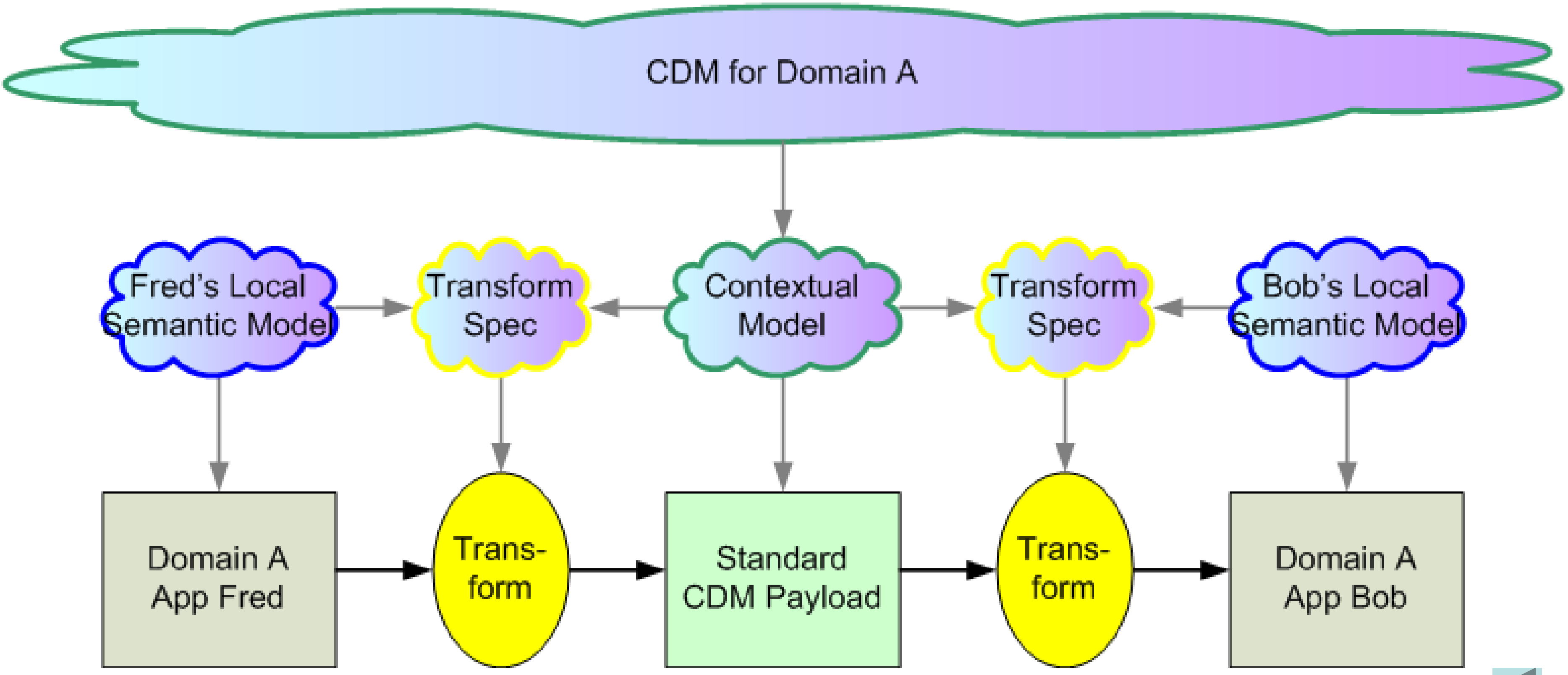
Example usage of CDM to define standard interfaces.



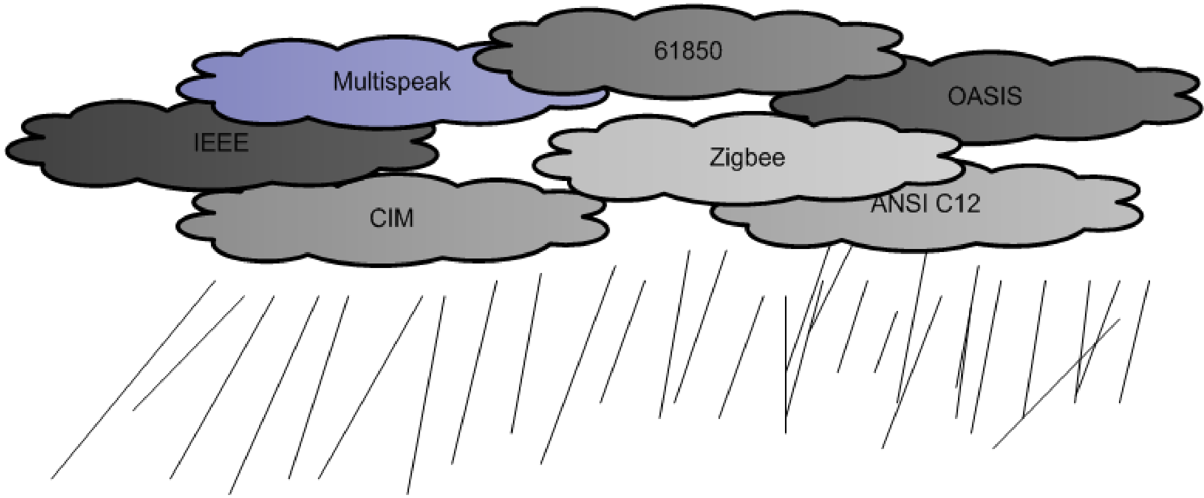
Considering the possibility of a single unified model.

- Definition: a ***unified*** model:
  - Is ‘normalized’ (no duplicate modeling of the same semantic).
  - Covers the entire problem scope of Smart Grid.
- Challenges:
  - A scope as large as Smart Grid has to be partitioned somehow into domains so that different focus groups can operate in parallel.
  - The difficulty of coordinating normalized modeling goes up exponentially with the number of different domains.
  - There is already significant investment in separate domain models which would have to be changed to achieve a global normalization.

Standard semantic integration within a unified domain – one CDM.



But the real world inevitably has multiple efforts to defined semantic standards.

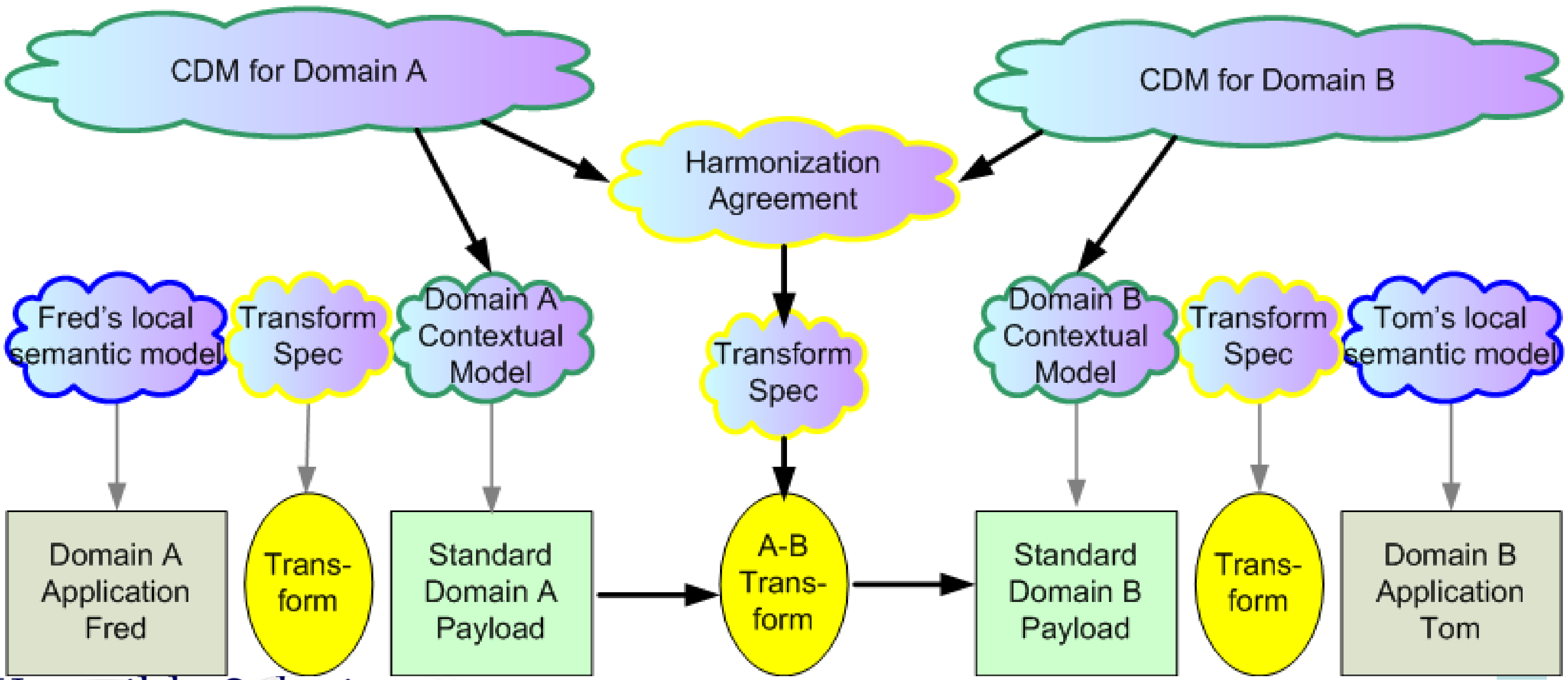


- Key questions:
  - What happens when CDMs collide?
  - How can we achieve maximum consistency, without killing business domain independence and initiative?
- This is what the Semantic Framework is trying to answer.

Harmonization: the next best thing for coordinating CDMs.

- Definition: two CDMs are ***harmonized*** if:
  - There is a lossless transformation defined between all duplicated semantics.
  - Both sides undertake to maintain the harmony, once established.

Standard semantic integration between harmonized domains – two CDMS.



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