Session 3: IT Architecture, Data Management, Cloud Services and Cyber Security

PART A: IT Architecture for Electric Utilities

Session Contents

- Evolution of the Electric Grid and the Changing Power Delivery Mechanism and its Impacts
- Smart Grid Architecture Model (SGAM) Framework and Interoperability Layers
- Service Oriented Architecture (SOA) for Utilities
- Software and Hardware Sizing and System Integration Considerations

Speaker:

Reji Kumar Pillai
President - India Smart Grid Forum

Chairman – Global Smart Energy Federation

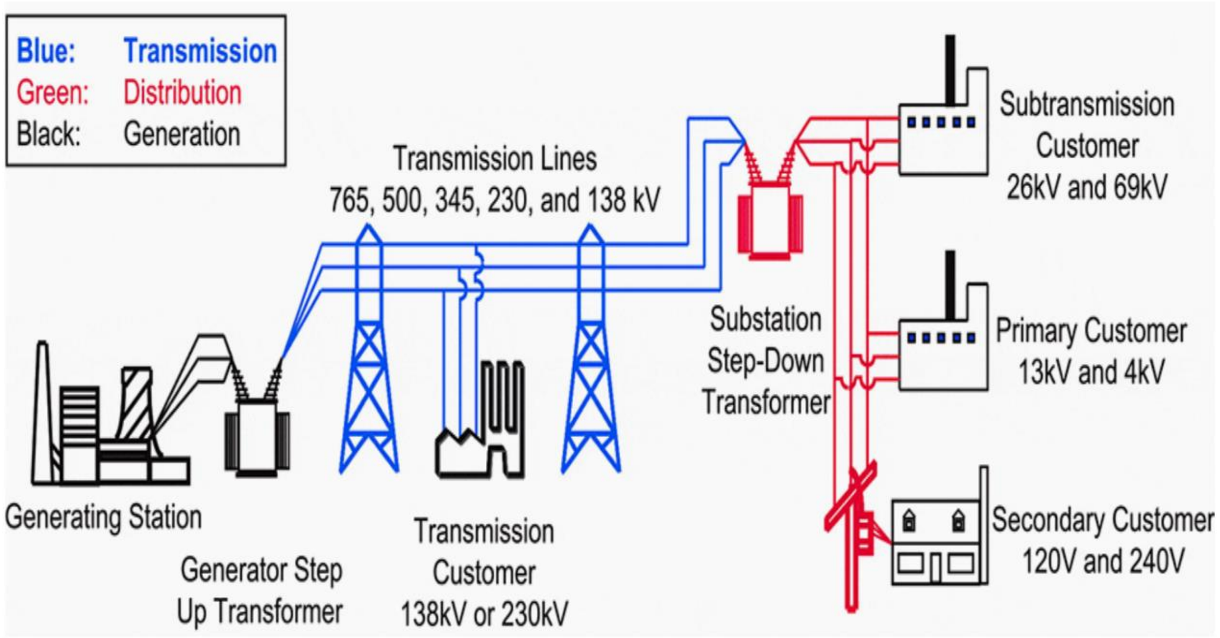
Evolution of the Electric Grid

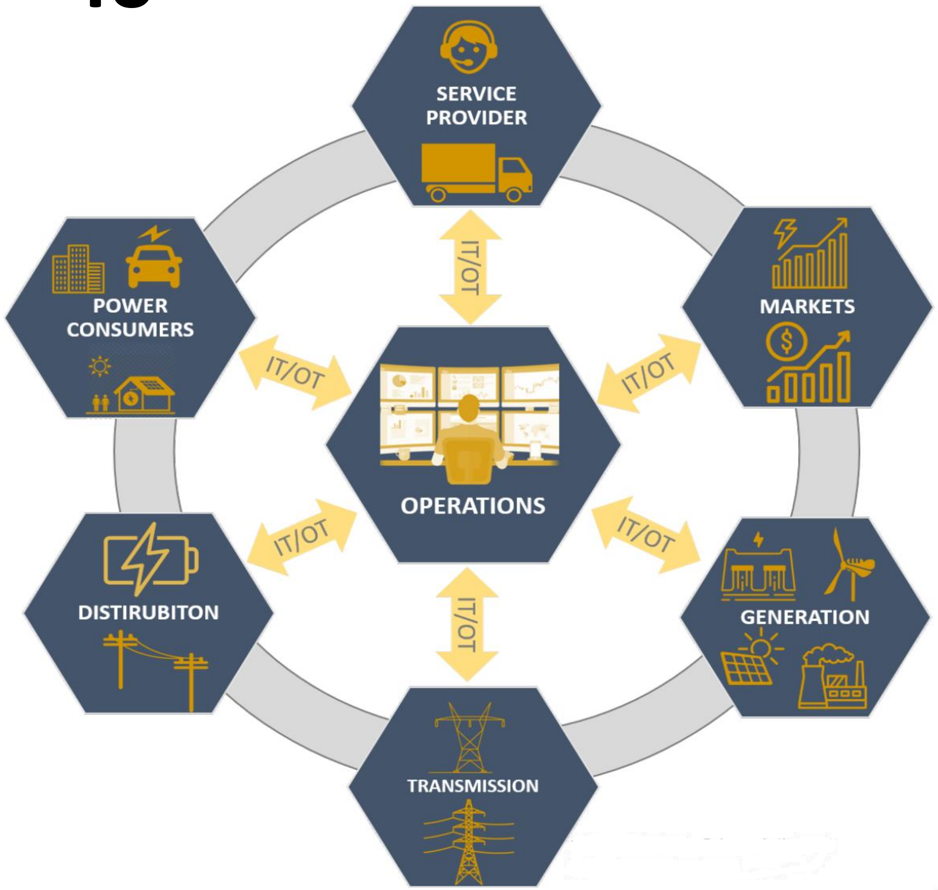
After a century of focus on centralized power generation and creation of massive electric grids, today the focus is towards de-centralized generation

- With more and more distributed generation resources being connected at the low voltage end of the grid, traditional boundaries between generation, transmission and distribution is fast disappearing - evolving into one "Integrated Grid"
- With consumers becoming "prosumers", the grid that is designed and built for one-way flow of electricity is now experiencing bi-directional flow of electrons
- Debate on whether to invest in transmission or in storage – the choice between "Generation + Transmission + Distribution" AND "Distributed Generation + Storage + Distribution" is real
- Power purchase is moving from Volumetric Tariffs to Transactive Tariffs as Inflexible Demand has become Price Responsive Demand: Era of Smart Energy OR Transactive Energy
- Loads have changed – Incandescent lamps and motors that could accommodate frequency and voltage excursions comprised majority of the load on the grid in the past. In the digital word new loads need quality power at constant frequency and voltage
- The "Merit Order Dispatch" has graduated towards an "Energy Efficient and Environmentally Responsible Dispatch" regime
- Solar PV has already achieved grid parity in most parts of the globe and is about to unleash a rooftop PV revolution
- Large fleets of Electric Vehicles that can be aggregated as virtual power plants and could support short term supply-demand balancing will make the grid even more dynamic and complex

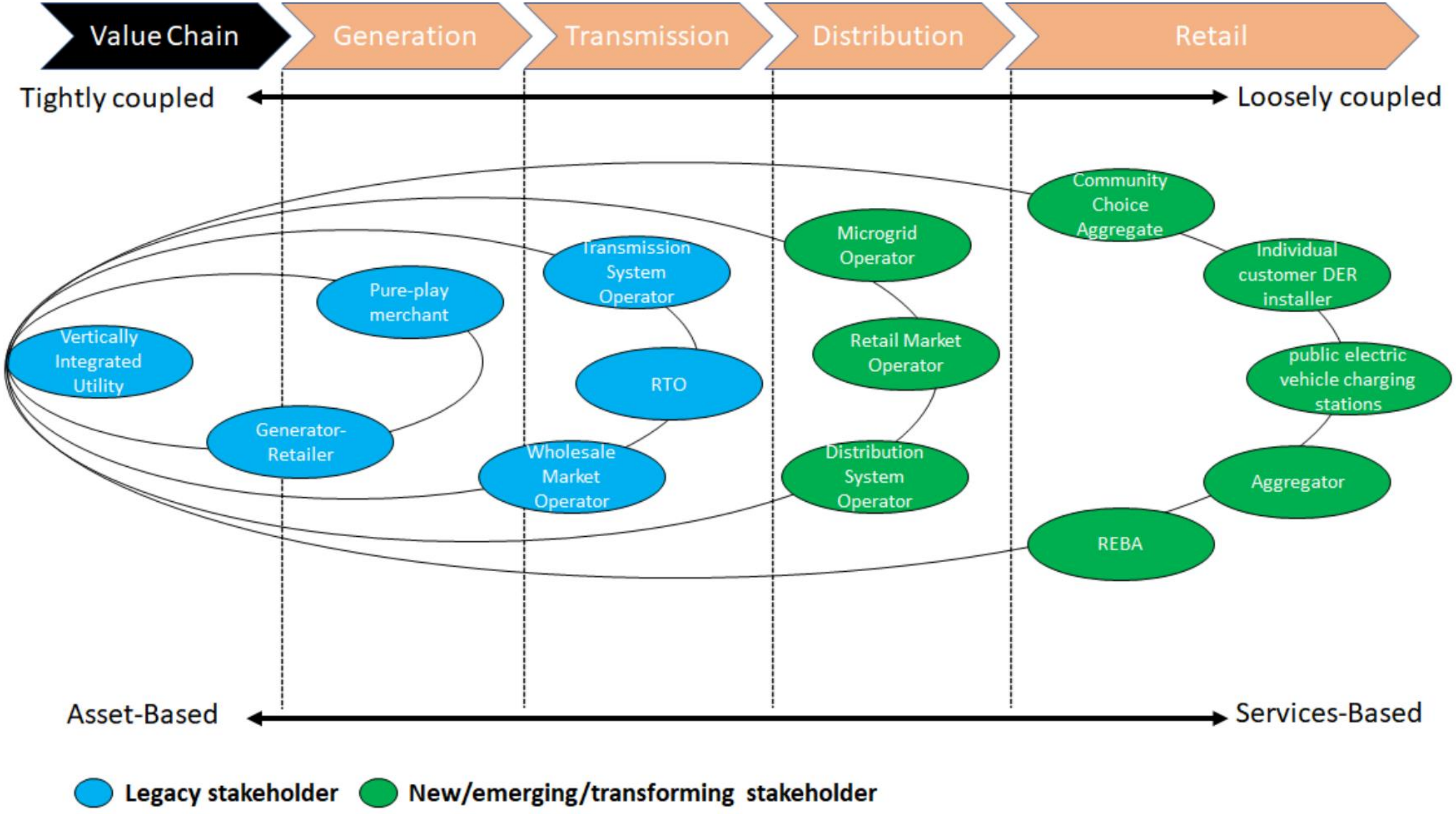
Changing the Power Delivery Mechanism

From → To



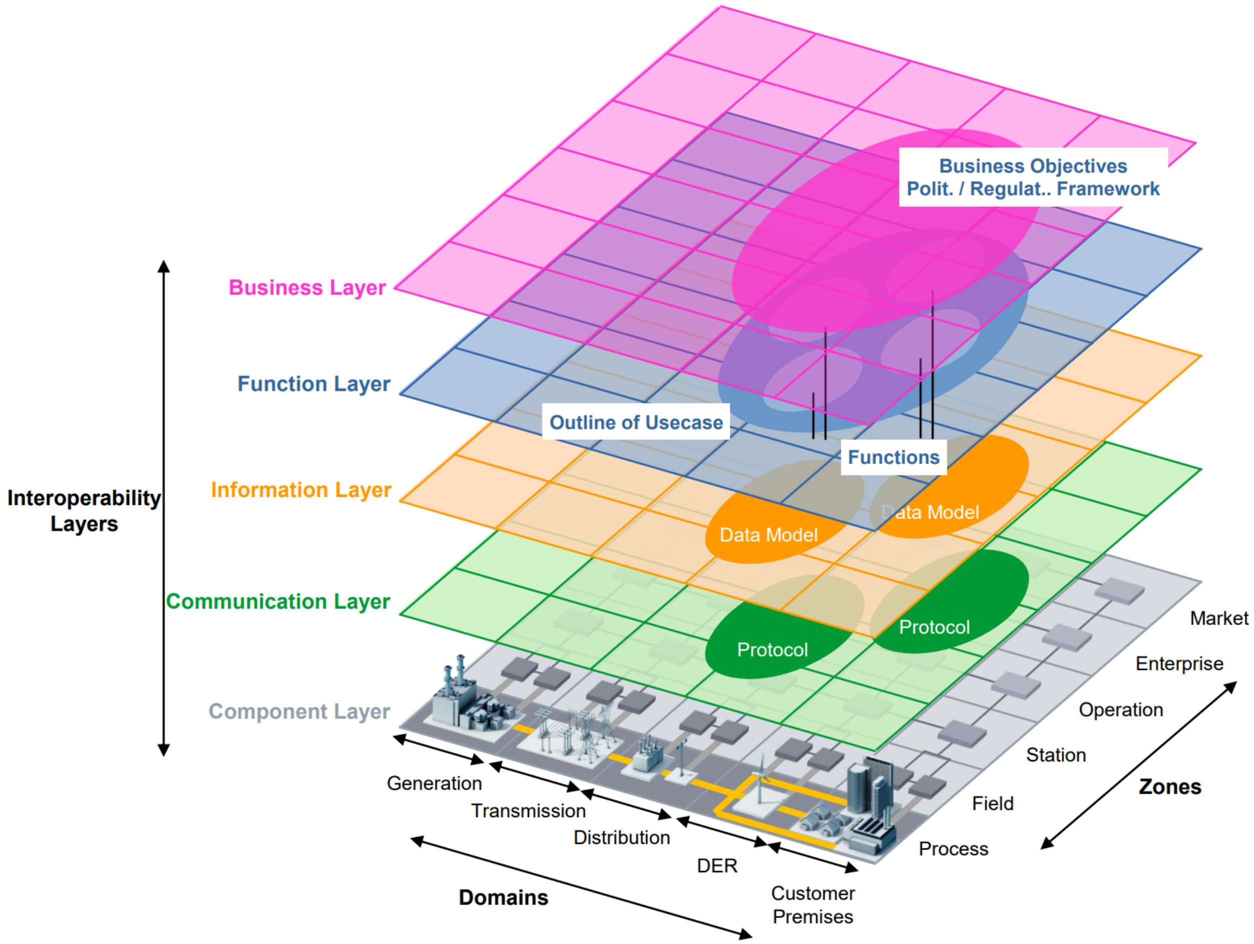


Impact of Changes along the Energy Value Chain



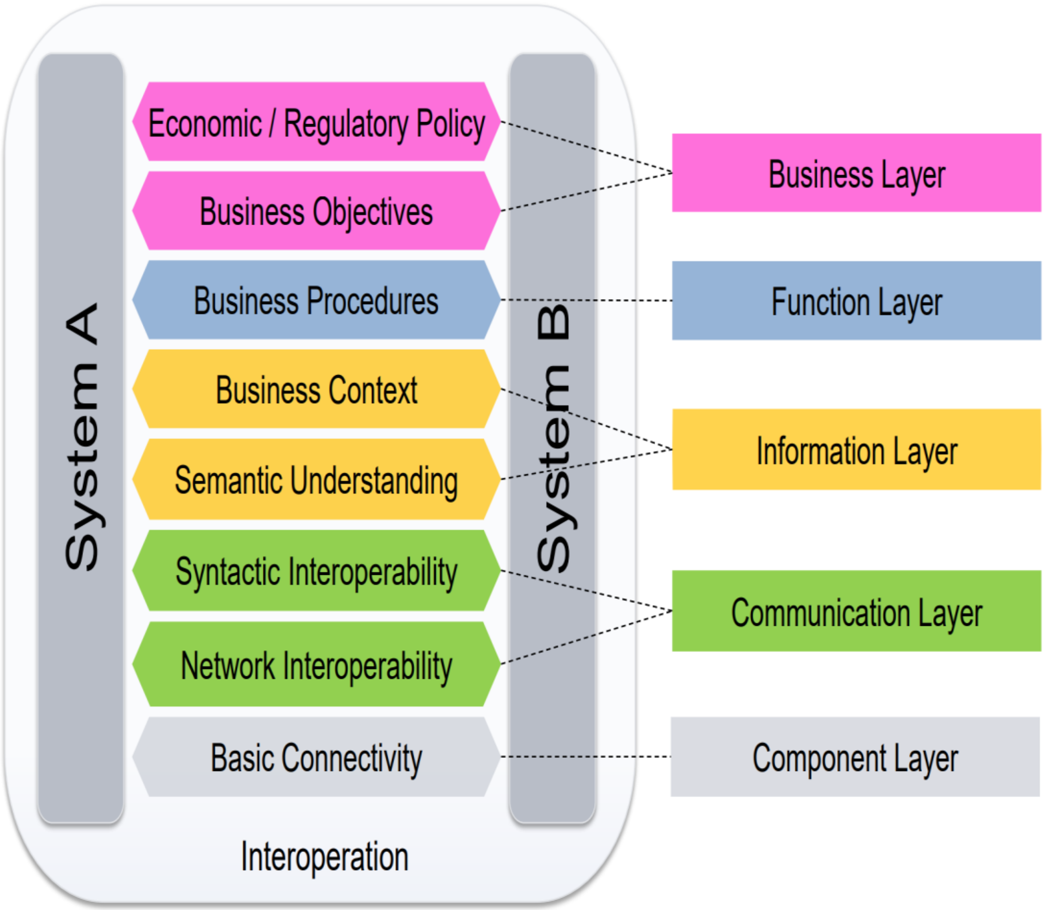
Smart Grid Architecture Model (SGAM) Framework

SGAM concept issued by European Commission in 2013 (M490)
Globally followed Architecture for Smart Grids



SGAM Interoperability Layers

- **Economic/Regulatory Policy:** Political and economic objectives as embodied in policy and regulation
- **Business Objectives:** Strategic and tactical objectives shared between businesses
- **Business Procedures:** Understanding of the scope and task of specified function
- **Business Context:** Understanding of the use of the information for a specified function
- **Semantic Understanding:** Understanding of the concepts contained in the message data structures
- **Syntactic Interoperability:** Understanding of data structures in message data structures
- **Network Interoperability:** Mechanism to exchange messages between multiple system across various networks
- **Basic Connectivity:** Mechanism to establish physical and logical connections between systems



Services Oriented Architecture (SOA) makes key IT capabilities available in new ways

SOA Definition

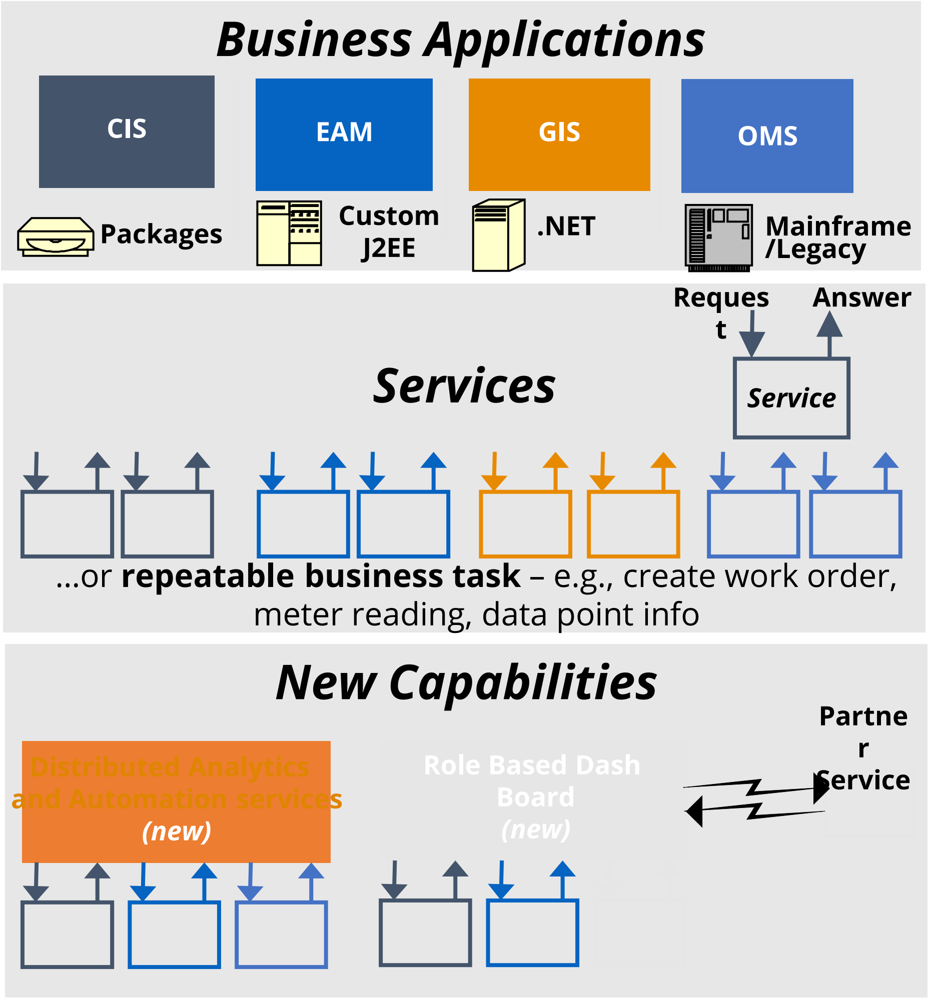
A ***service-oriented architecture (SOA)*** is an architectural framework that takes business applications…

…and breaks them down into *services*…

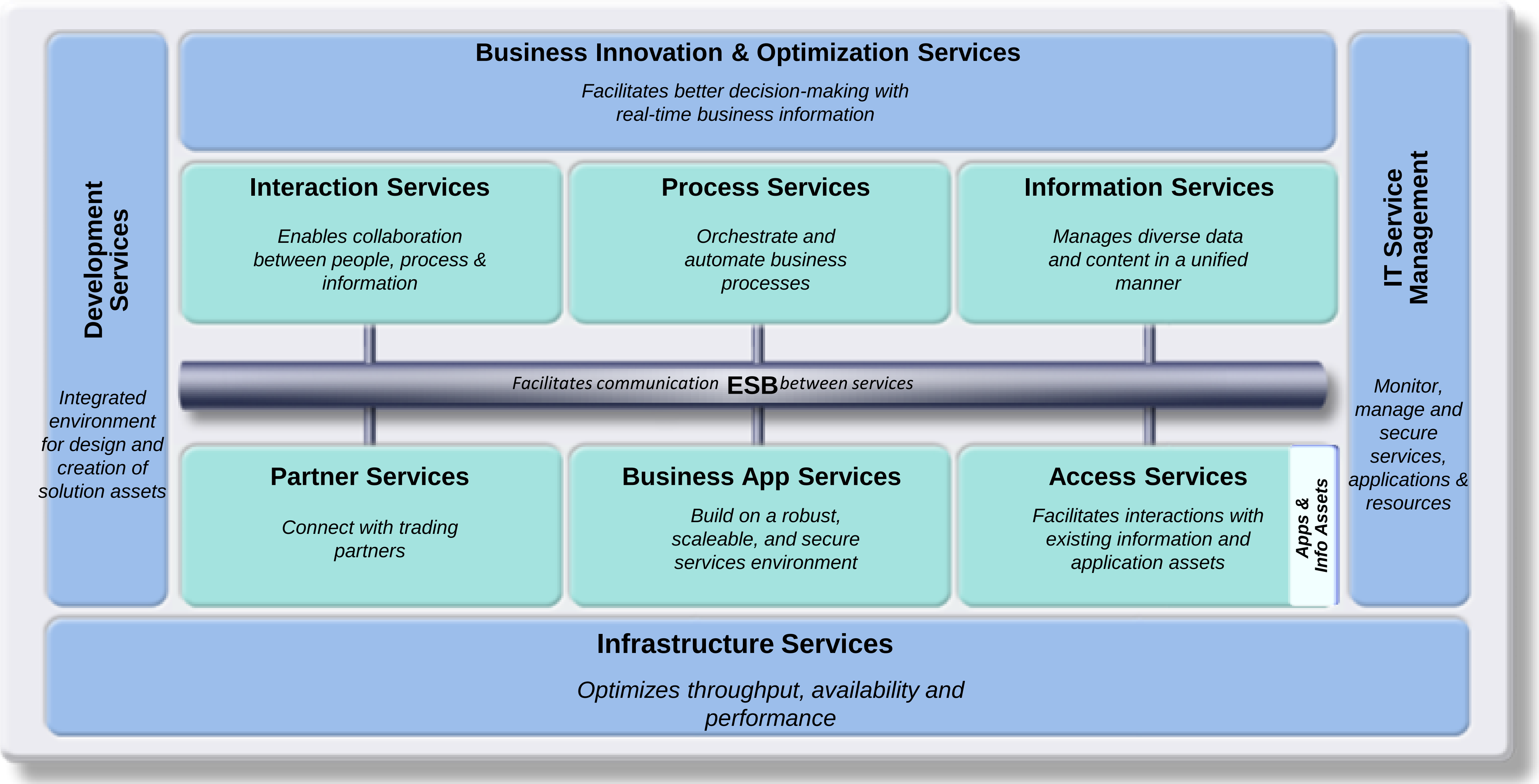
…that can be made available for use ***independent of the applications*** and the computing platforms on which they run

These services can be integrated and used to build *new capabilities such as distributed Network Analytics and Automation services…*

…supporting ***new functionality*** from within the current portfolio or from the extended value chain



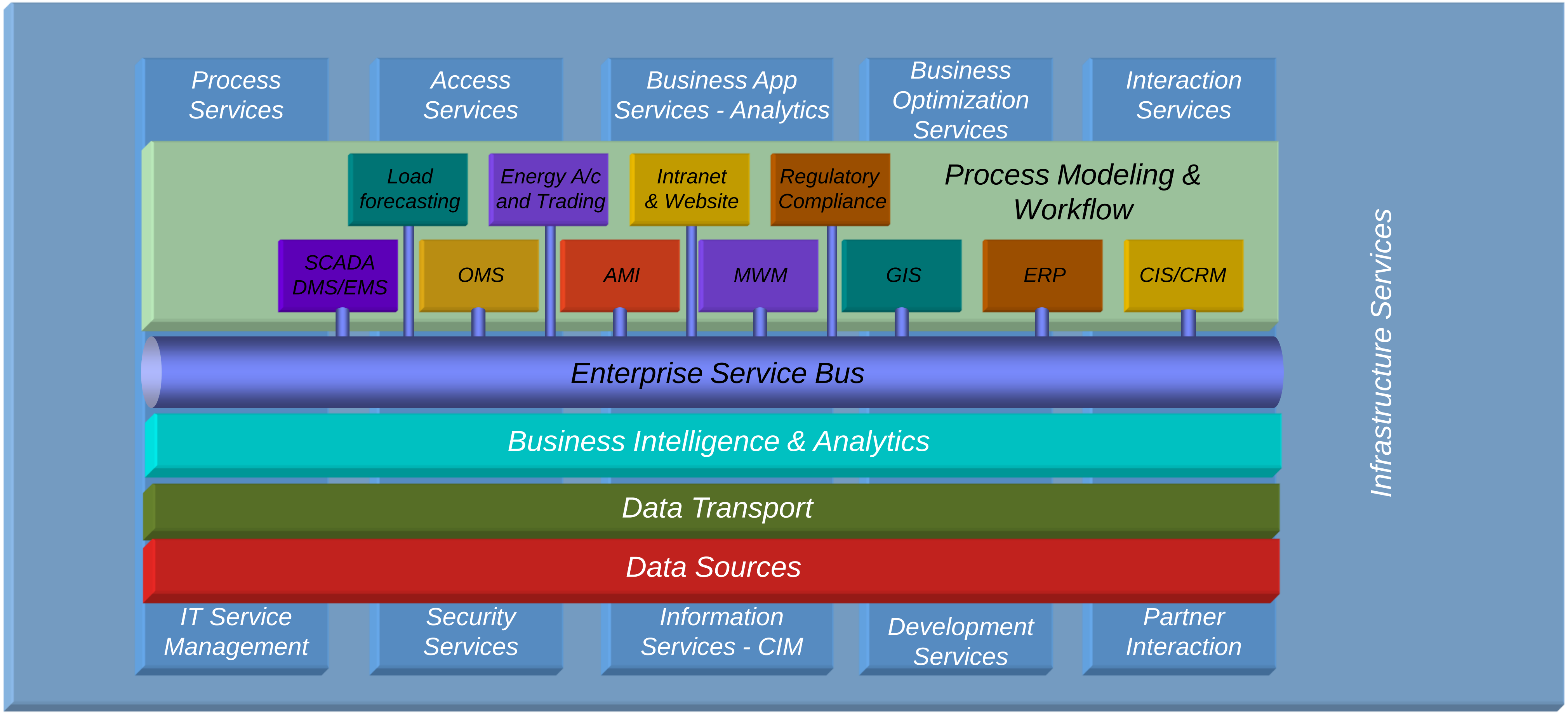
SOA Reference Architecture



SOA means different things to different people – IT Architecture for some while for others it is Business Services

	Roles	
Capabilities that a business wants to expose as a ***set of services*** to clients and partner organizations	**Business**	
An ***architectural style*** which requires a service provider, requestor and a service description. It addresses characteristics such as loose coupling, reuse and simple and composite implementations	**Architecture**	
A ***programming model*** complete with standards, tools, methods and technologies such as Web services	**Implementation**	
A ***set of agreements*** among service requestors and service providers that specify the quality of service and identify key business and IT metrics	**Operations**	

Solution Architecture of a Distribution Utility



***An architectural blueprint** to support the integration of applications and new services of a Utility*

PART B: Cloud Services

Session Contents

- What is Cloud Computing
- Traditional Infra v/s Cloud Infra; and Benefits of Cloud Computing
- Models of Cloud Computing
- IT/OT Landscape
- Cloud Architecture Principles and Considerations for Running AMI Solutions on Cloud

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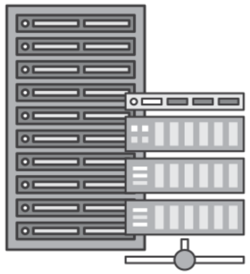
What is Cloud Computing?

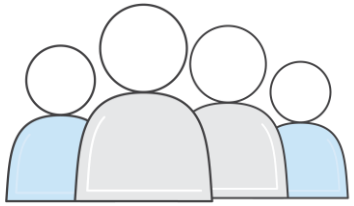
"Cloud Computing," by definition, refers to on – demand delivery of IT resources and applications via the Internet with pay-as-you-go pricing

Traditional Infra Vs Cloud Infra

Traditional Infrastructure



Equipment



Resources and Administration

Contracts

Cloud Infrastructure

No Up-Front Expense Pay for what you Use

Improve Time to Market & Agility

Scale Up and Down

Self-Service Infrastructure

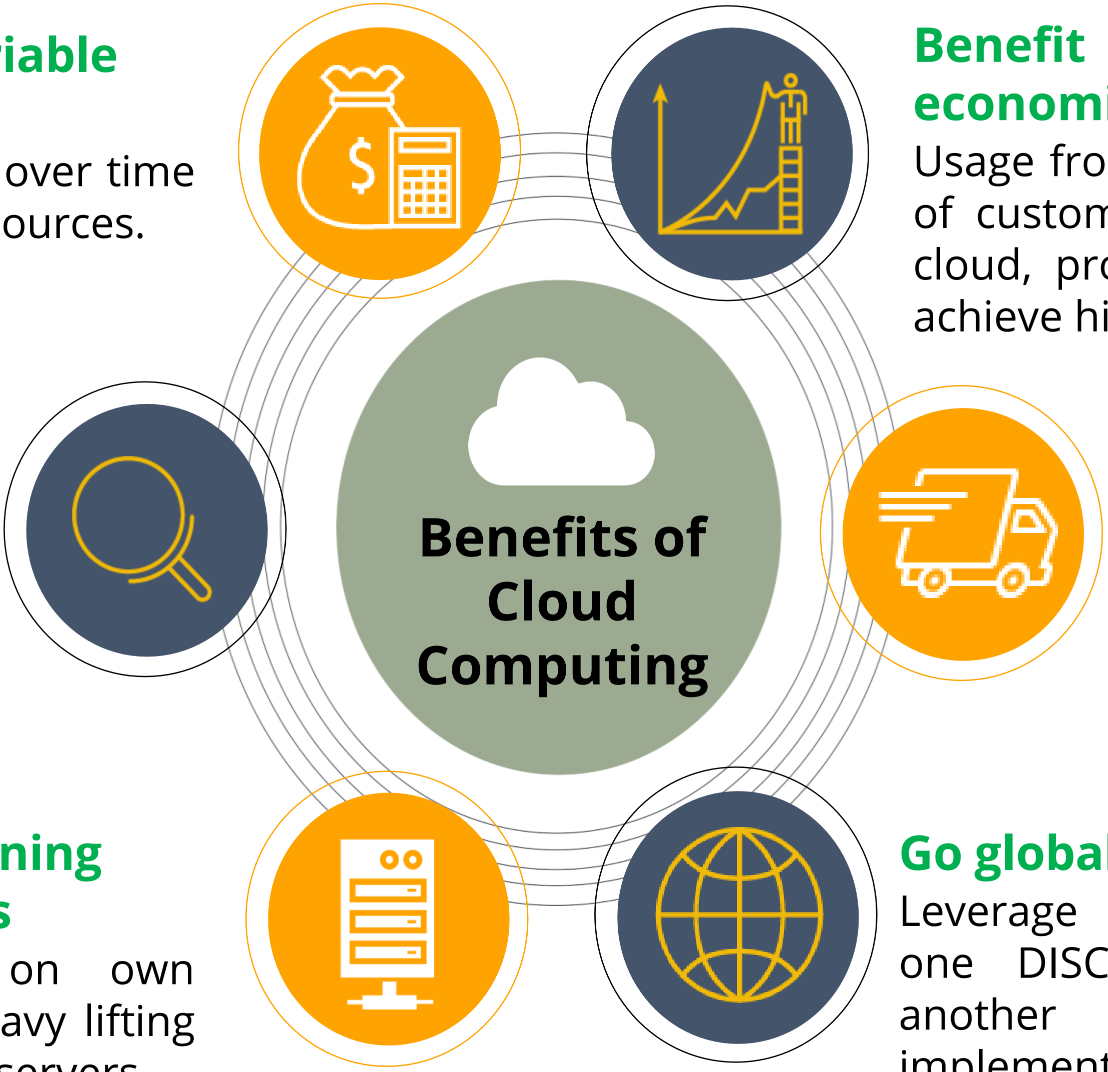
Benefits of Cloud Computing

Trade capital expense forvariable expense

Installed meter volume increases over time and proportionate computing resources.

Benefit from massive economies of scale

Usage from hundreds of thousands of customers is aggregated in the cloud, providers such as AWS can achieve higher economies of scale.



Stop guessing capacity

Variable workloads for meter data acquisition schedules, VEE process, billing determinants requests.

Increase speed and agility

Agility to leverage new services to churn insights from meter data, integrate with new services like AI/ML.

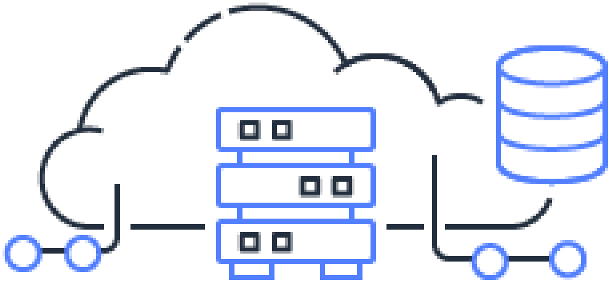
Stop spending money on running and maintaining data centers

Cloud computing lets focus on own customers, rather than on the heavy lifting of racking, stacking, and powering servers.

Go global in minutes

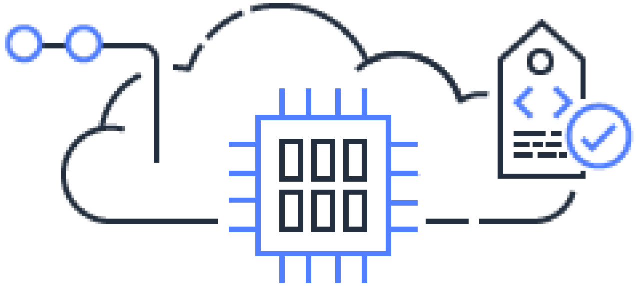
Leverage resource configuration from one DISCOM's implementation for another DISCOM and reduce implementation efforts.

Three Main Models for Cloud Computing



Infrastructure as a Service (IaaS)

Contains the basic building blocks for cloud IT and typically provide access to networking features, computers (virtual or on dedicated hardware), and data storage space.



Platform as a Service (PaaS)

Remove the need for organizations to manage the underlying infrastructure (usually hardware and operating systems) and allow you to focus on the deployment and management of your applications.

Software as a Service (SaaS)

Provides a completed product that is run and managed by the service provider. In most cases, people referring to Software as a Service are referring to end-user applications.

Architecture Principles and Considerations for Running AMI Solutions on Cloud

Architecture Principles	Architecture Considerations
Performance Efficiency	**Managing variable workloads and meeting performance requirements** • Use serverless architectures; Democratize advanced technologies and opt for managed services • Use purpose-built databases
Operational Excellence	**Run workloads effectively with visibility into their operations, and improve supporting processes** • Measure execution times of key AMI processes; Make use of cloud native resource monitoring tools • Use 'pre-mortems' to anticipate failures and create procedures to handle these
Reliability	**Ability of a work- load to perform its intended function correctly and consistently** • Use auto-scaling to cater to variable loads; Define mechanisms to automatically recover from failure • Scale horizontally to increase aggregate workload availability
Security	**Protection of meter reads and associated data, and the resources managing data** • Protect data in transit and at rest; Apply security at multiple layers; Enable traceability
Cost Optimization	**Optimize cost of running AMI applications on cloud considering the trade-offs** • Stop spending money on undifferentiated heavy lifting; Adopt a consumption model
Sustainability	**Improve power efficiency (may be switching to graviton-based instances in future)** • Choose serverless when possible • Integrate Cloud Instance Scheduler to shut down and terminate when not in use • Use Cost analysis for right-sizing recommendations of workloads

Thank You

Any questions?

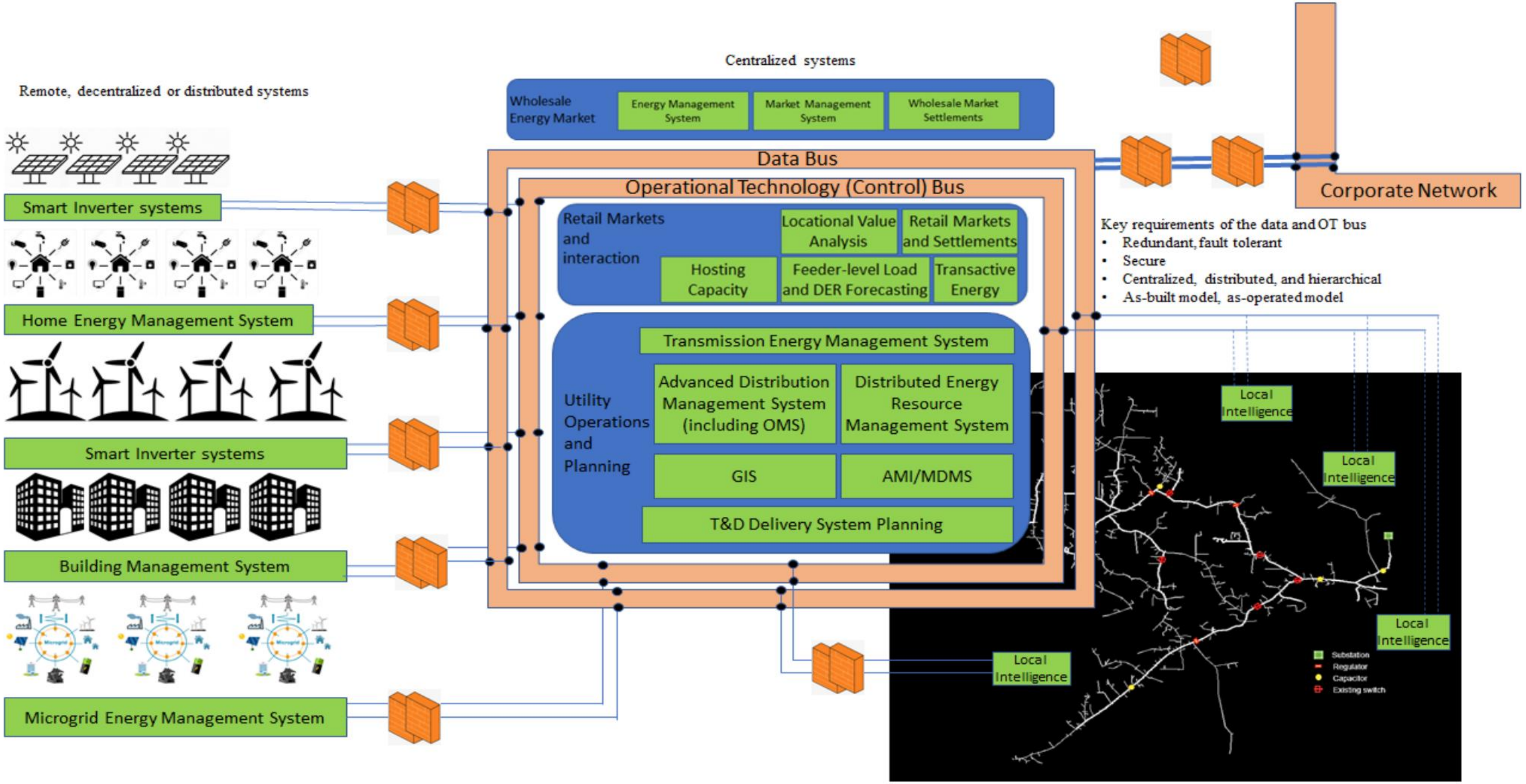
Reji Kumar Pillai

reji@rejikumar.com

@rejipillai

Annexes

A Logical Architectural Construct of the Future Grid



Logical Architectural Construct of the Future Grid

- **Two new types of buses:** The IT/Data bus and the OT/Control bus:
  - The IT/Data bus is responsible for carrying all the non-operational models and information necessary to drive utility decisions
  - The OT/Control bus is responsible for carrying all the operational data and control actions taken at the local level, centralized level, or other levels in-between, should they exist
- **Standardized and Open Interfaces:** Implementing a standards-driven architecture allows the entire suite of solutions to become more flexible, nimbler, and capable of changing faster while keeping up with the industry's changing needs.
- **Standardized Tools and APIs:** Standardized utilities/tools/functions are the crux to making the next generation of architecture work.
- **Standards-based and Sstandardized Models:** Establishing and utilizing a standard allows for modeling the various components to be done in a structured manner using a common approach.
- **Self-rregistration of Devices, Applications and Systems:** The electric grid is like a computer network in that computer, automation, and power system devices and components are continuously added and removed from the grid's network. Today, these changes are manually managed and maintained. The ability of these devices to "self-register" and advertise their existence and associated connection points on the grid is essential.

SOA will drive operational savings by reducing integration, operating and system maintenance cost

SOA Leads to Decreased System Costs

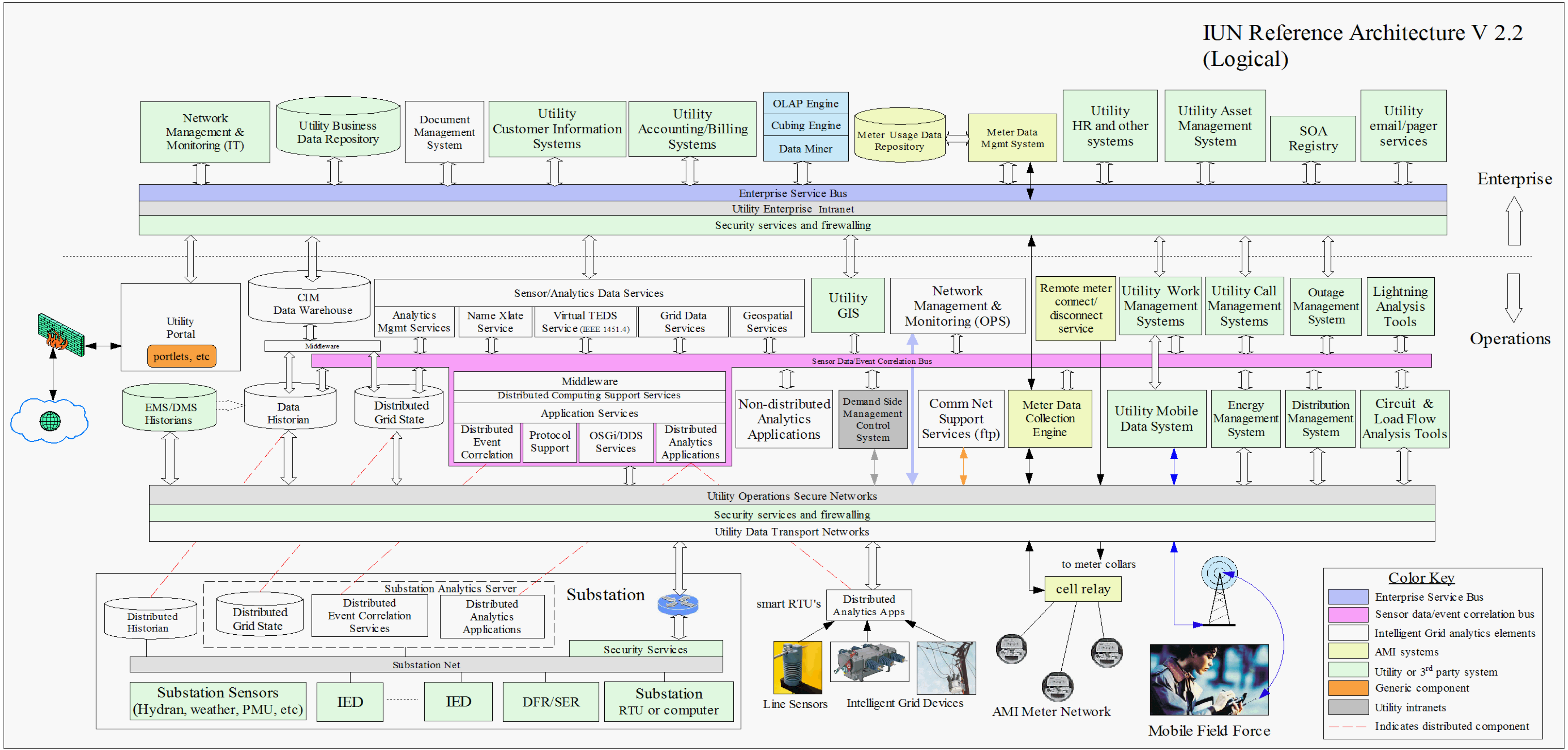
Reduce Systems Integration Costs	▪ Standards-based solutions reduce design time by limiting choices on many design decisions ▪ Standards-based solutions demonstrate lower cost to integrate than custom, point-to-point implementations ▪ Published-services-only push some cost to external service users (partners, suppliers)
Reduce Operating Costs	▪ SOA solutions demonstrate lower redundancies in system capabilities and to improve efficiencies in source code management ▪ Increased atomicity of design allows solutions to be built supporting more flexible business processes. This results in decreased business and operational costs.
Reduce Systems Maintenance Costs	▪ Systems with a higher degree of reuse have less code to maintain ▪ Financial burden for maintaining shared code can be shared across the organization ▪ Higher utilized code has higher quality, resulting in lower error rates and resulting lower costs to change & test ▪ Standards-based solutions demonstrate lower maintenance costs than custom, point-to-point implementations

Software and Hardware Sizing and System Integration Considerations

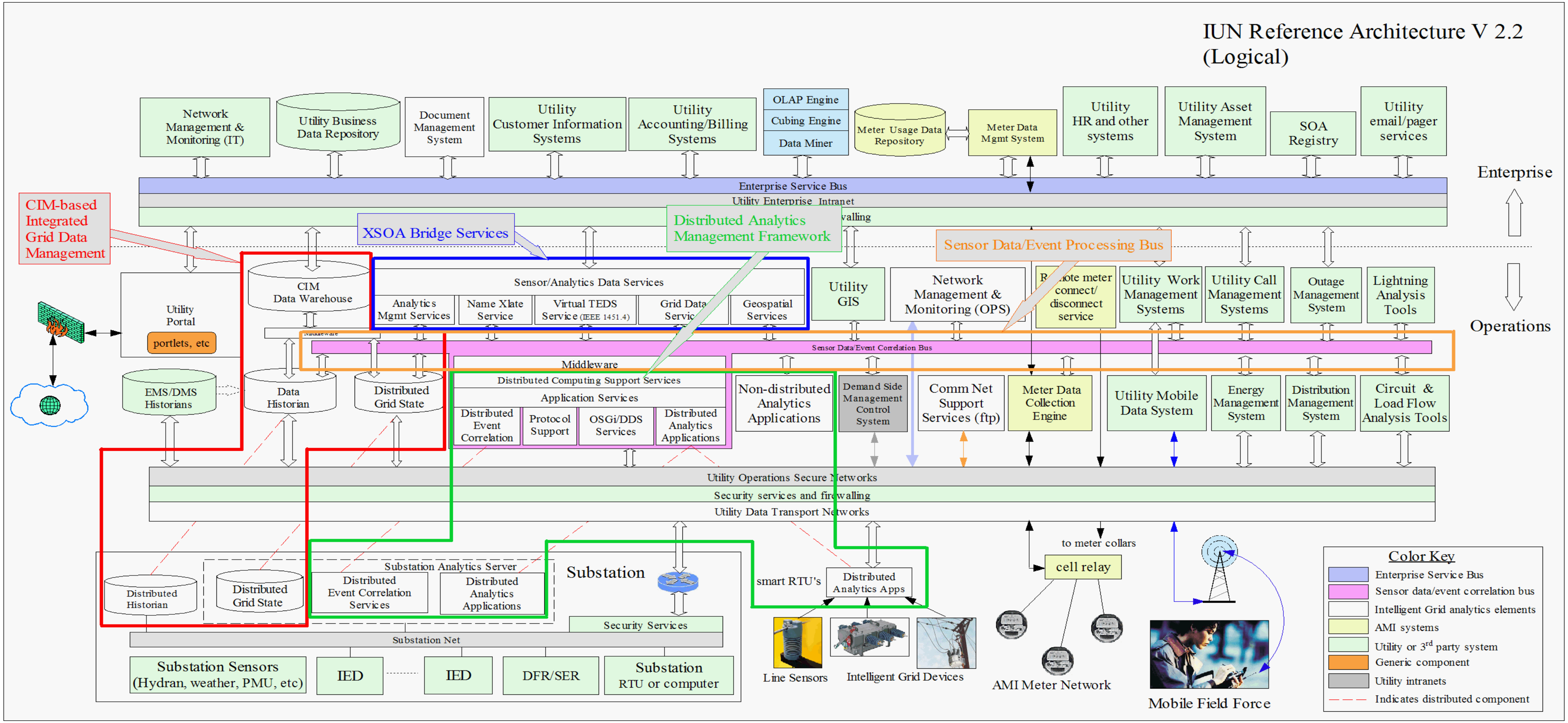
Software Sizing	Number of Users of the Application; and maximum concurrent Users Data Size; Database sizing and management strategies Dependencies of the Application on other systems Cyber Security measures planned Integration requirements with existing/new systems Need for disaster recovery and data backup solutions
Hardware Sizing	Hardware Sizing depends on the software sizing Network bandwidth and latency requirements for optimal performance Virtualization and its impact on hardware resources Hardware lifecycle and replacement strategies Requirements of system enhancements in near future
System Integration	Standardize data formats and communication protocols Prioritize encryption and access controls for data safety Set up continuous monitoring for performance and security Maintain detailed documentation for system configurations Provide training to IT staff and users on new integrations

Examples from IBM on Building SOA for Utilities

IBM's Intelligent Utility Network (IUN) Reference Architecture

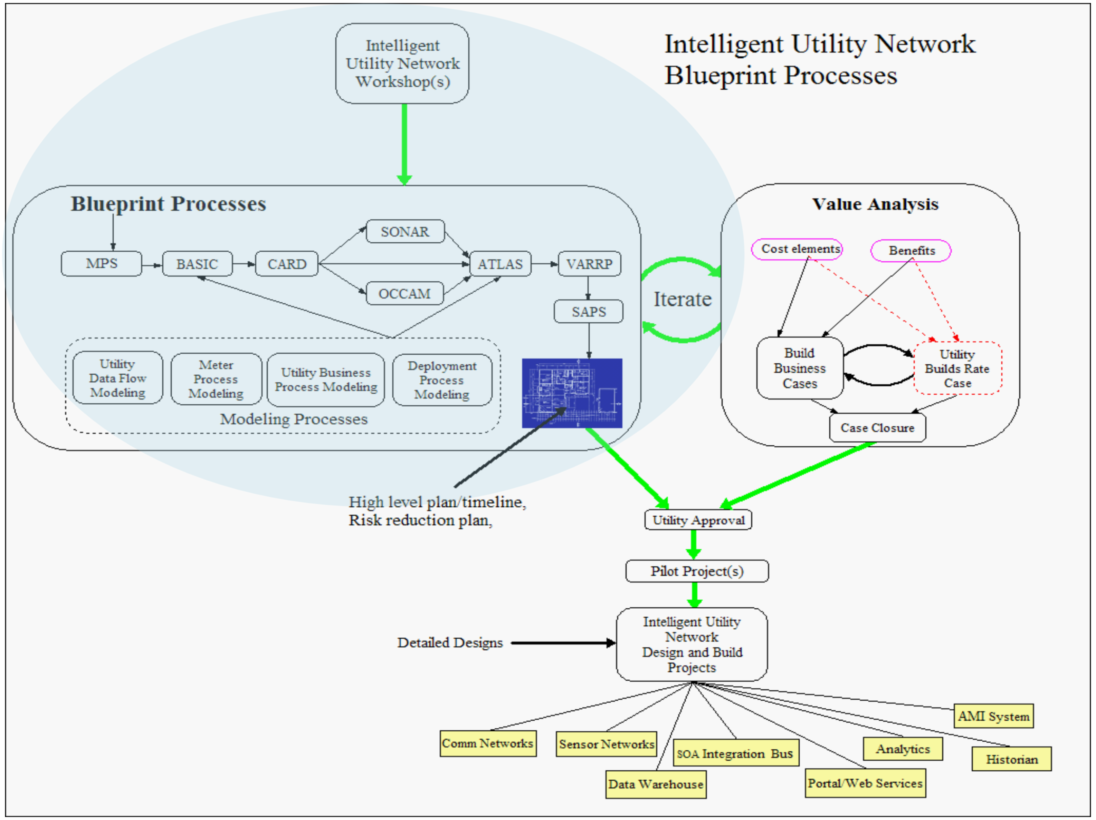


XSOA Elements of IUN Reference Architecture (IBM)



Getting started: the first recommended step in the process of architecting a solution is building a blueprint

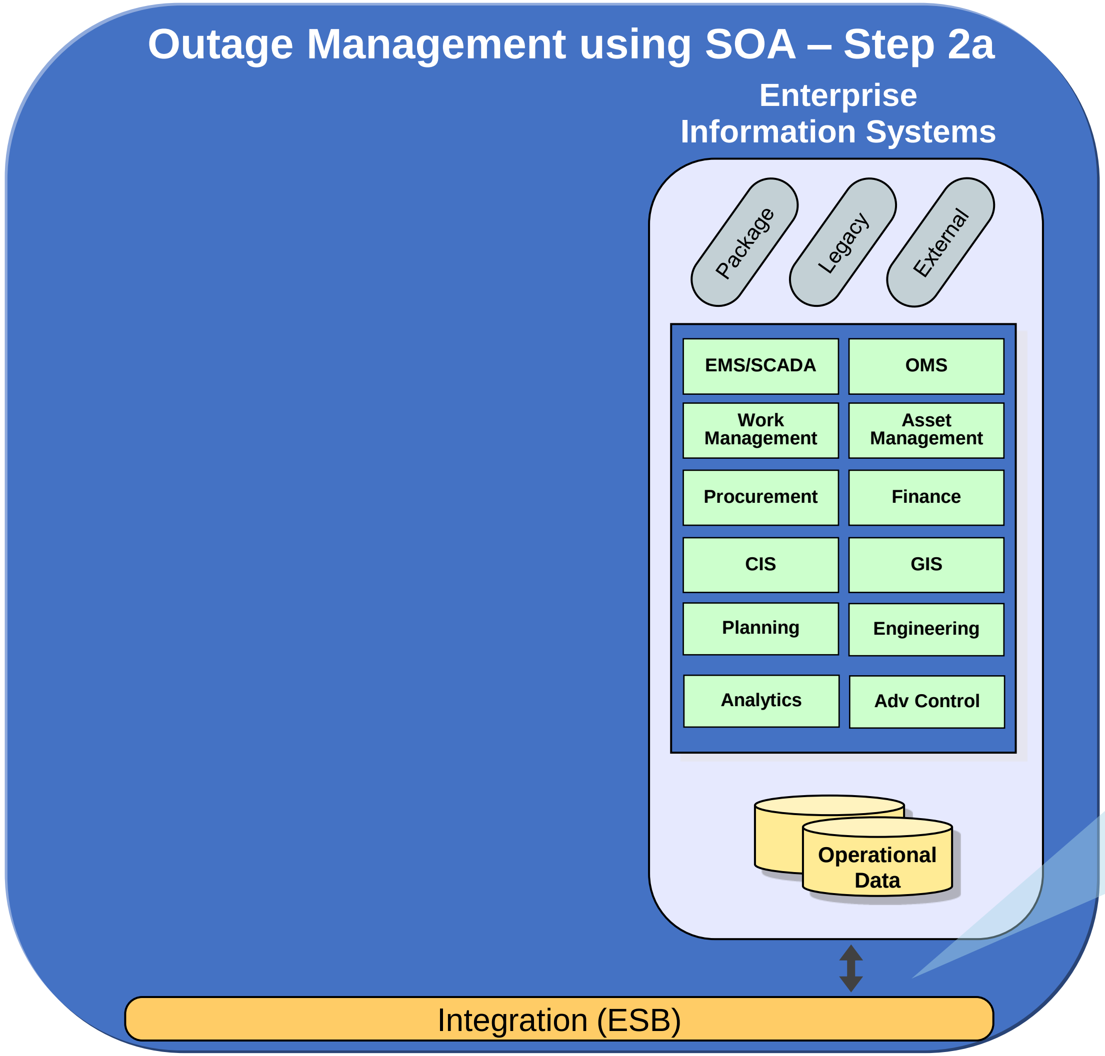
Example: Outage Management using SOA – Step 1



Blueprint Processes:

- MPS – MetaProcess Specification. Before beginning the detailed Blueprint processes, we and the client mutually agree on a set of operating rules that will govern the rest of the project
- BASIC – Baseline and Systems Inventory Compilation. We prepare a compilation and characterization of the utility's existing systems, software, applications, facilities, skill sets, and equipment that apply to the Intelligent Grid
- CARD – Constraints and Requirements Definition. We prepare a document that defines the mission for the Intelligent Grid, the constraints that apply, and the requirements for the Intelligent Grid
- SONAR – Sensor Optimization and Network Operating Requirements. This is a process for determining the best placement of sensors to support the various applications identified in the CARD process
- OCCAM – Optimal Comparative Communications Architecture Methodology. This methodology provides a rational process and tool set for sorting out utility communications requirements vs. technology options and provides a set of high-level design and business case templates for best choices that match specific utility requirements and constraints
- ATLAS – Applications, Timeline, and Architecture Specifications. This document set is the actual roadmap. It incorporates the results of the BASIC and CARD processes with a preliminary high-level architecture for the utility's Intelligent Grid, along with an approximate timeline for incremental implementation
- VARRP – Variations and Risk Reduction Planning. Risk reduction projects are small-scale field tests and pilot projects, designed to reduce risk by identifying risk areas and performing tests to validate assumptions, model, verify equipment or system behavior and performance, etc. There may be one or several pilots for a given Intelligent Power Grid project
- SAPS – Standards and Practices Specification. This process provides for the identification and selection of key standards and practices that will be used in the development of the client's Intelligent Utility Network

Once the blueprint is in place, implementation begins with enabling an integration platform

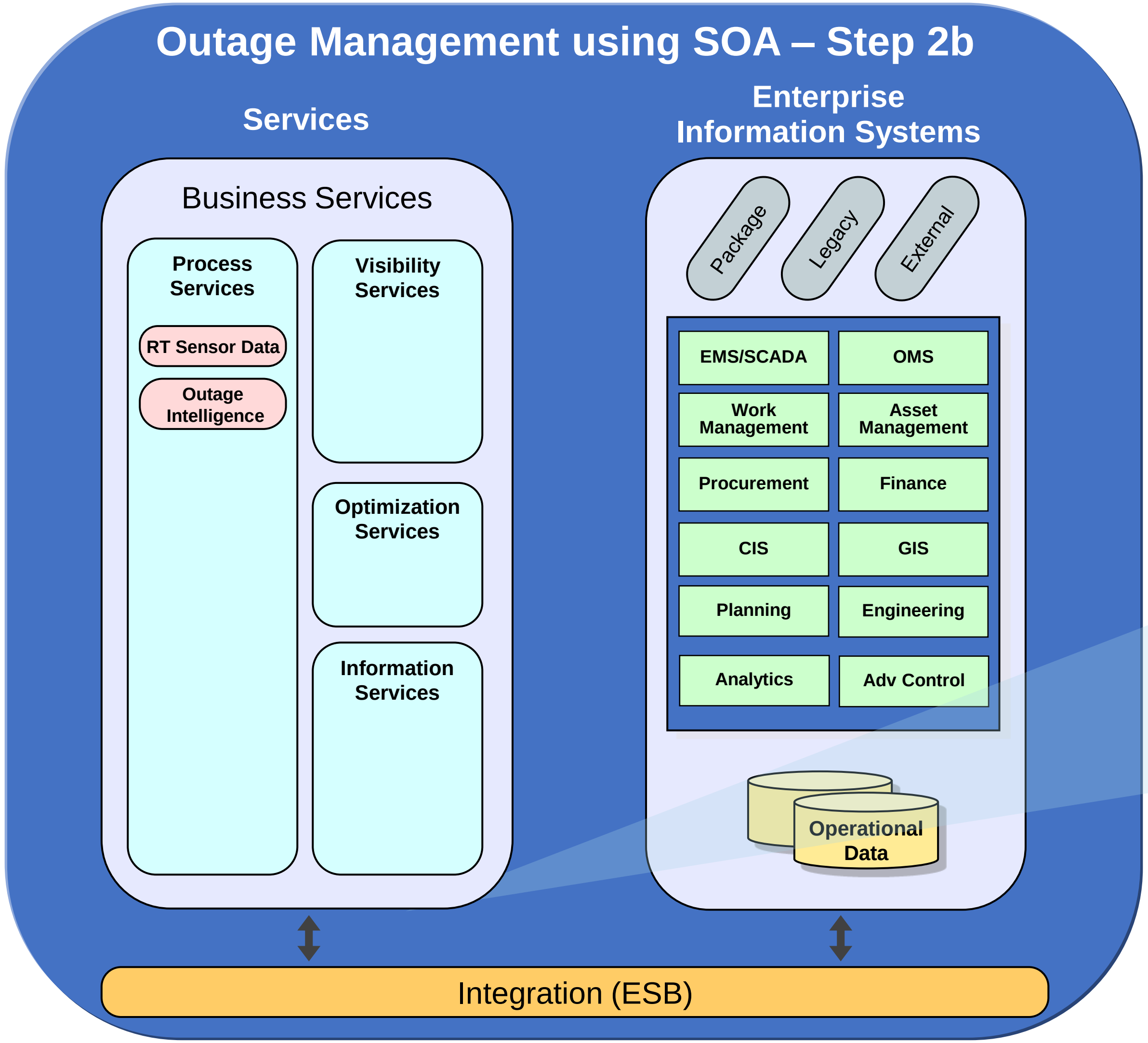


Enable the SOA Infrastructure with the Integration Bus

Enable an Integration Architecture

- Define the EAI framework for systems like *EMS/SCADA, OMS*, *Work Mgmt, Asset Mgmt* etc.
- For a more common implementation approach, we would recommend an ESB product

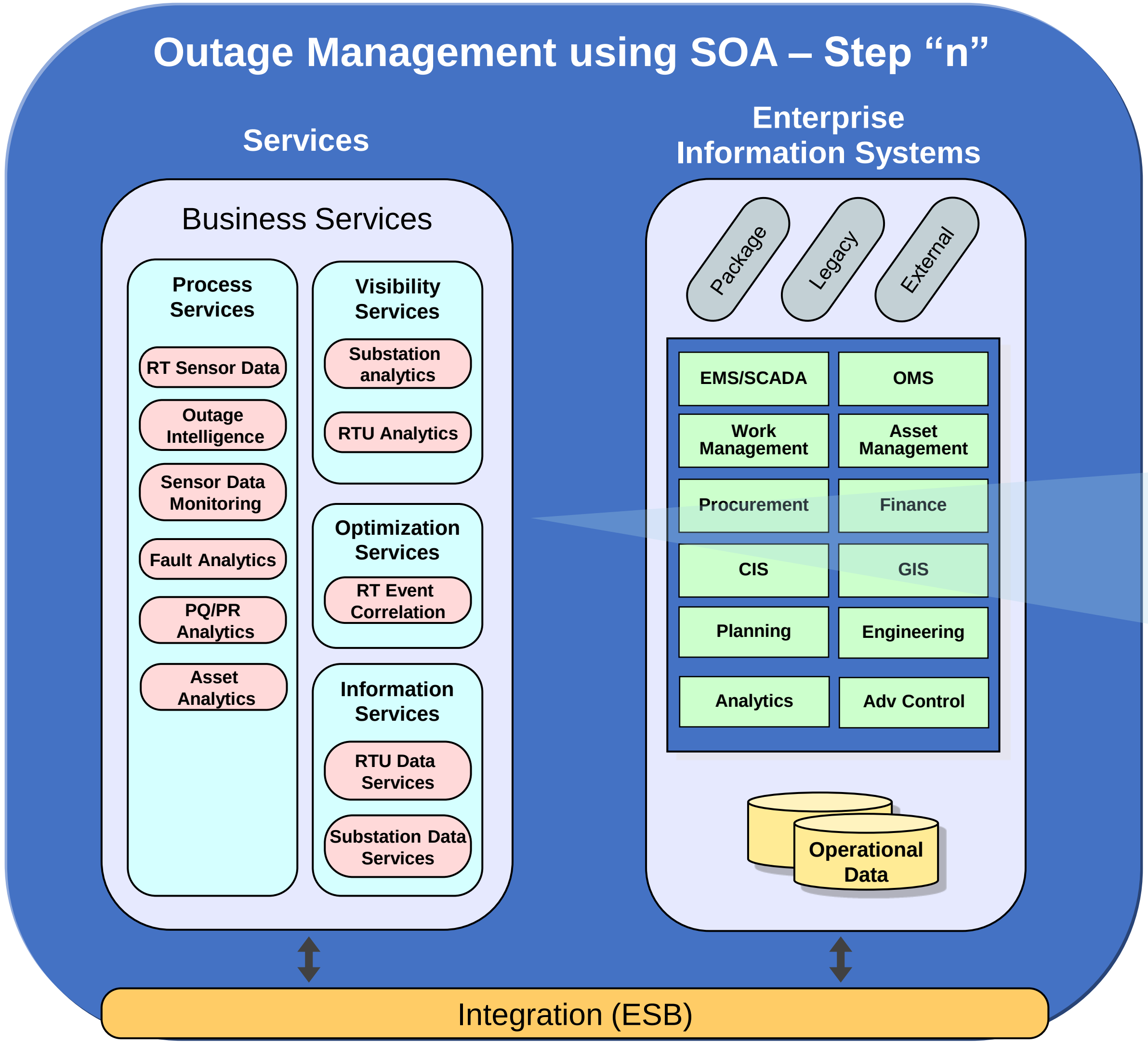
Next, business services are created and communicate through the Integration Bus (ESB)



Make incremental additions by exposing Business Services through the Integration Bus

- Identify Services to enable processes and determine sources for implementation (EMS/SCADA, OMS, Work Mgmt, Asset Mgmt etc...)
- Define, common Data Model/Ontologies based on standards like CIM
- Expose Legacy functionality as a service
  - •Create/Reuse adapters for EMS/SCADA, OMS, Work Mgmt, Asset Mgmt systems and ISVs/packages
  - •Enable new Business Services
  - •Enable *RT Sensor Data* Services and *Outage Intelligence* Services leveraging ‘EMS/SCADA, OMS, Work Mgmt, Asset Mgmt and first Notice. Systems.

Over time, additional services and processes can be added



Re-use and accelerate as more processes are enabled from the base integration platform already built

- Integration Architecture, Adapters for legacy have been implemented in prior steps
- Roll out of new SOA enabled processes is done by leveraging and reusing existing adapters
- Additional features and functionalities are enabled incrementally by exposing services from current legacy systems
- In a SOA Architecture, adding processes for better business value becomes easier by leveraging COTS, ISVs or third-party service providers

Business Services are defined as ‘process’, ‘visibility’, ‘optimization’ or ‘information’, each playing a distinct role in the architecture

Business Services

Types / Services	Description	Process Services	Visibility Services	Optimization Services	Information Services
Domain Services	▪ These services are manifestation of the business domain of an enterprise ▪ They are very specific to the domain for which they are built e.g. Services related to support ‘DMS’ only domain or Services related to support ‘OMS’ Only domain ▪ These services should not be shared even though technically it may be possible to share them	▪ Supports Business processes/Sub processes/Activities/Tasks that can be automated ▪ Manifestation of the above processes as single service ▪ Can be an atomic or composite service leveraging other services through choreography ▪ Process Services are subscribable as well as provisional. ▪ Process Services consist of multiple access services that make the process service subscribable as well as enable access to back-end system, resources, and remote services	▪ More data/Information related ▪ Supports Business Support Systems and Reporting Needs ▪ Generally, Supports Read Only Transactions etc.	▪ A business service that optimizes another business service ▪ Optimization services discover, diagnose, and adapt dynamically to changes in the business processes or transaction using domain-specific policies ▪ Optimization Services operate at the business component and process level --they make dynamic business process and transaction handling decisions based on user delegated tasks and real-time metrics from Visibility Services	▪ Provides Common Information related Services ▪ Data Encryption Services ▪ Data transformation which are domain specific ▪ Data validation ▪ Content & Document Management Services ▪ Example : CIM Processing Service
Shared Services	▪ These are business Services but with high level of NFR support from Infrastructure and governance perspective since their re-use level across enterprise is assumed to be very high ▪ Shared across enterprise ▪ Shared within a LOB (limited reusability) to shared across LOB – high reusability ▪ Impacts Infrastructure Planning/Critical SLAs/Governance				

Technical Services are defined as 'security', 'data', initialization' or 'systems management' types

Technical Services

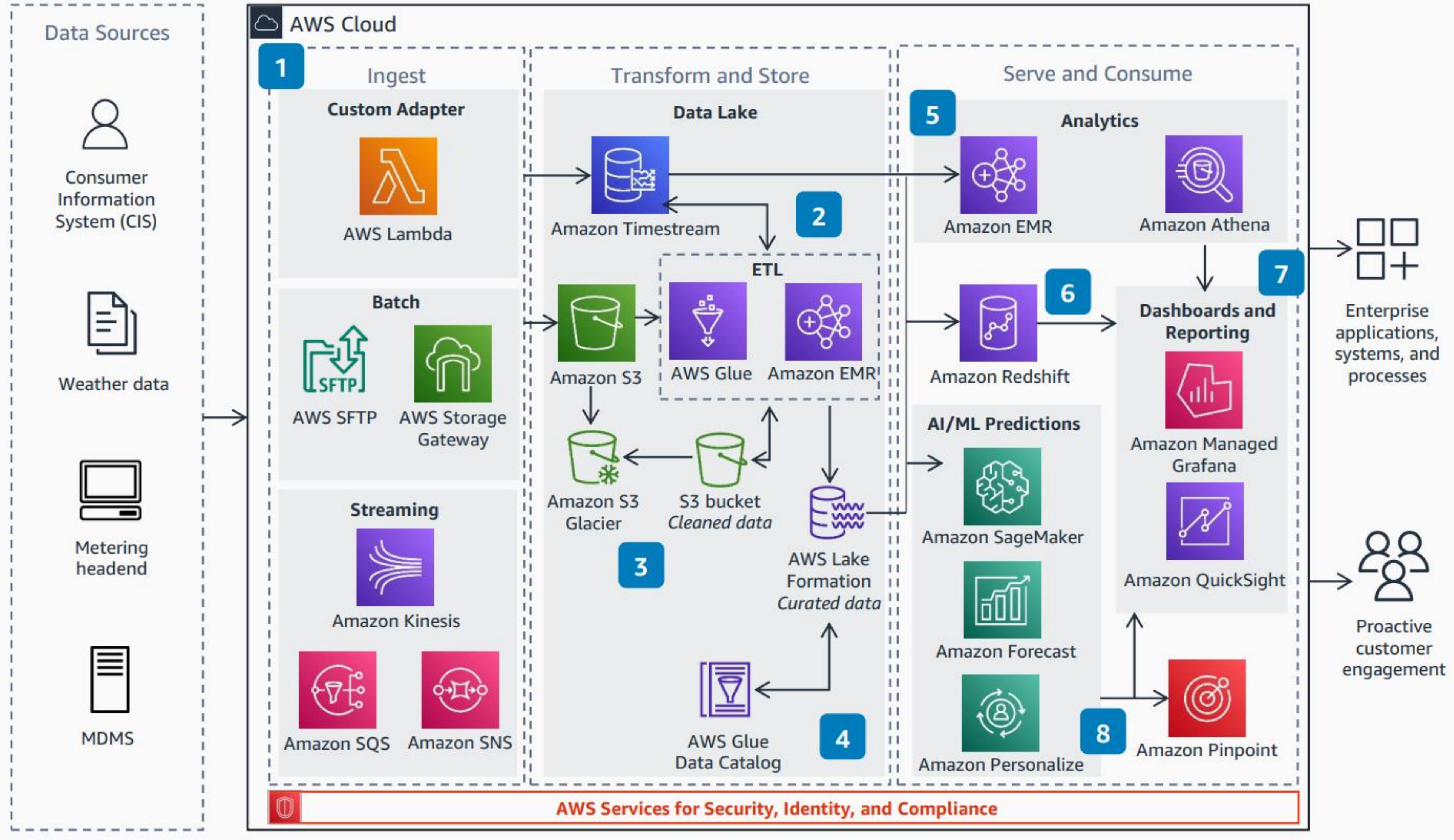
Types / Services	Description	Security Services	Data Services	Virtualization Services	Systems Mgmt. Services
Infrastructure Services	▪ Technology Related Services which lends Infrastructure/Technical Support to functional Applications and Services ▪ Provides Systems Management functionality ▪ Provides Security related Services	▪ Provides Services dealing with security aspects related to both Applications and Infrastructure ▪ Example Services like Authentication, Authorization, Non-Repudiation, Encryption and Decryption of data etc.	▪ These are services providing generic data related functions needed by the enterprise ▪ It provides ETL related functions ▪ It provides services needed for data transformation	▪ TBD	▪ Provides services related to the systems management aspect of the enterprise ▪ Error Notification ▪ Deployment and Distribution of Software ▪ Availability support needed by the applications ▪ Scheduling functionality needed for applications.
Application Support Services	▪ Provides Common Support Needed for application ▪ Session management/UI services				

Services can be used and re-used across business processes – without the need for re-definition

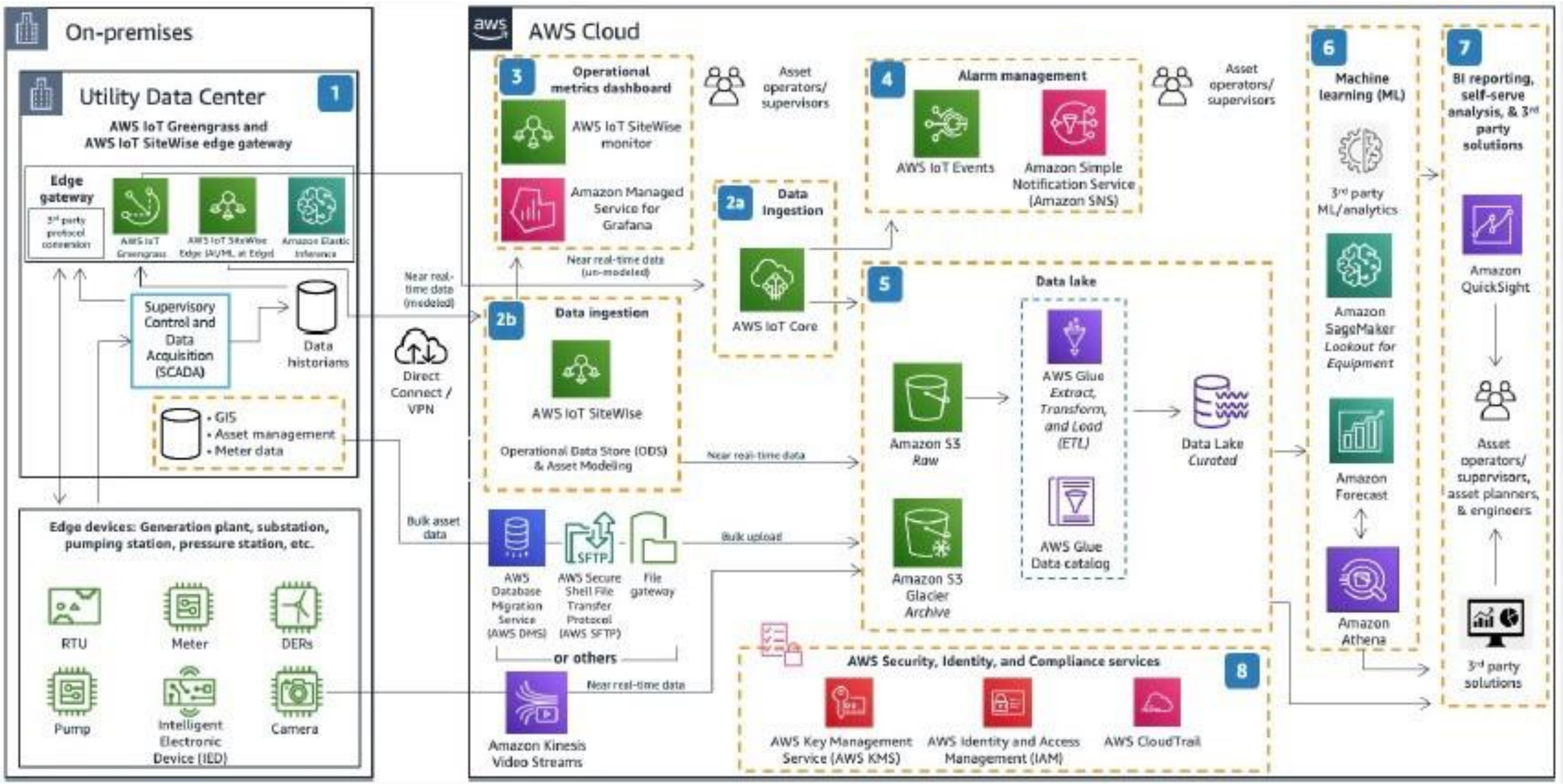
Utility Business Processes / Example Service Categories	Grid Ops	Outage Mgmt	Fault Detect	Sys Perf Meas	PQ Mgmt	Asset Mgmt	Work Mgmt	Opt	Sys Plan-ning
Sensor Data Svcs	*	*	*	*	*	*	*	*	*
Event Corr Svcs	*	*	*				*		
Outage Intel Svcs	*	*	*						
TEDS Svs	*	*	*	*	*				
Fault Analytics Svcs	*		*	*			*		
Sensor Data Monitoring Svc	*					*		*	
Asset Analytics Svc	*					*	*		
PQ/PR Svcs								*	*
Name Translation Svc	*	*	*	*	*	*	*	*	*
Substation Analytics Svcs	*	*	*	*			*		
Substation Data Svcs	*	*	*	*					
Sensor Data Storage Svcs	*	*	*	*	*	*	*	*	*
RTU Data Svcs	*	*	*		*				
RTU Analytics Svcs	*	*	*		*				

Examples from AWS on Running Analytics on Cloud

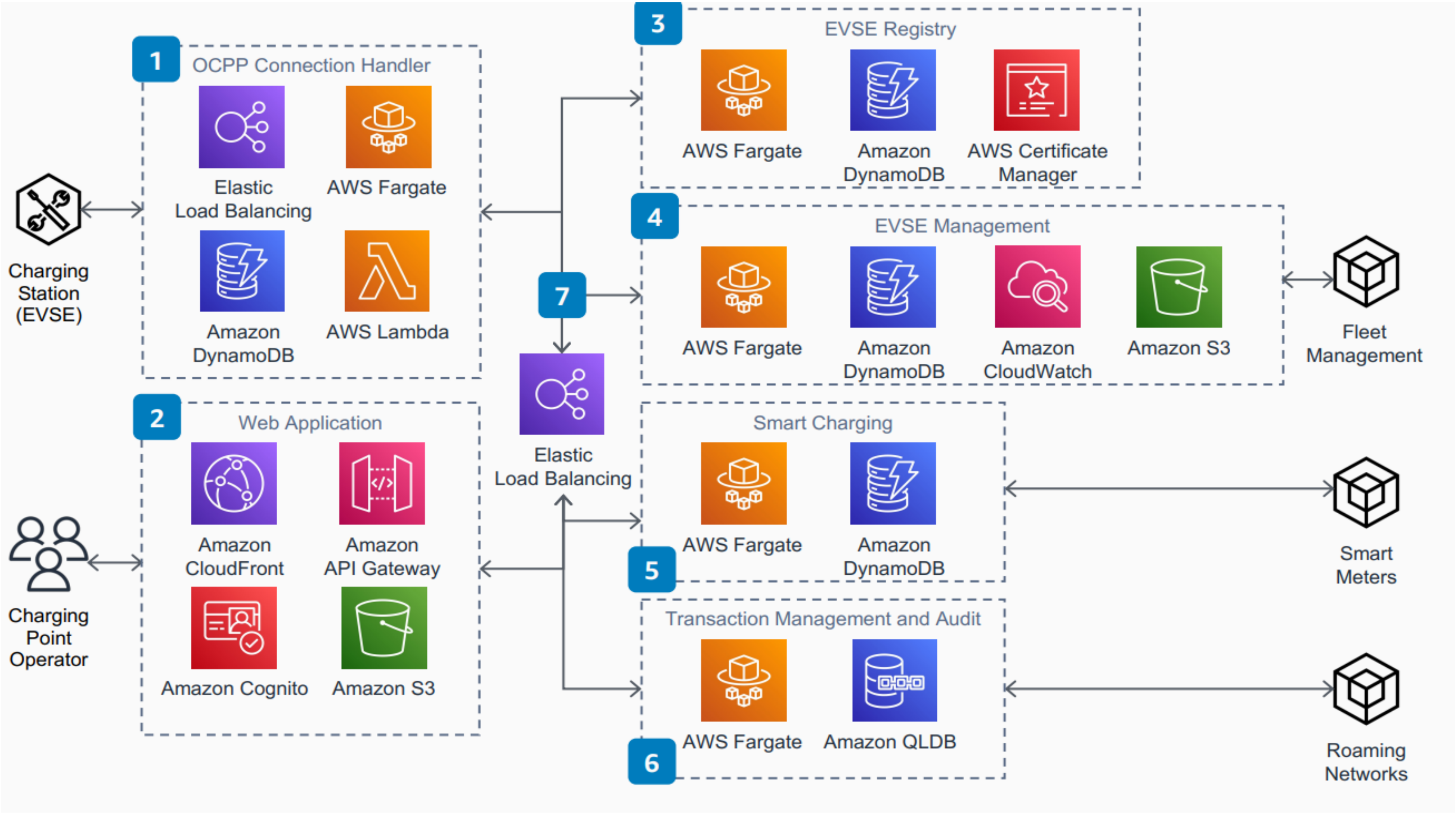
Meter Data Analytics Platform for Utilities



Predictive Equipment Health for Utilities



Electric Vehicle Charging Station Management Software



Renewable Asset Analytics on AWS