Model Driven Architecture Enabling Service Oriented Architectures

Rakesh Radhakrishnan
Lead IT Architect
(Communication Market Area)
Mike Wookey
Distinguished Engineer

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Introduction and Overview

This paper attempts to highlight the significance and value proposition of leveraging the fundamental principle's and concepts behind "Model Driven Architecture" and "Service Driven Architectures" – what is more commonly referred to as "Service Oriented Architectures", for XML based "Web Services". "Web Services" being one of the later instantiations prior to which we've had CORBA or JINI based Services Oriented Architectures.

In Model Driven Architecture (MDA), modeling an enterprises system (data, systems, and model of your data model) in conjunction with meta-data, which keeps a record of an enterprise's architecture in-terms of data, information, application, services, technology and implementation (platform specifics) is the basis. There are three basic tools used in an MDA as defined by OMG (Object Management Group) – (see http://www.omg.org/mda):

> ***Meta-Object Facility (MOF)-*** *The MOF defines a standard repository for meta-models and, therefore, models (since a meta-model is just a special case of a model)*
> ***XML Meta-Data Interchange (XMI)-*** *XMI defines an XML-based interchange format for UML meta-models and models; by standardizing XML document formats and DTD (document type definitions). In so doing, it also defines a mapping from UML to XML.*
> ***Common Warehouse Meta-model (CWM)-*** *The CWM standardizes a complete, comprehensive metamodel that enables data mining across database boundaries at an enterprise and goes well beyond. Like a UML profile but in data space instead of application space, it forms the MDA mapping to database schemas.*

These three techniques in MDA in conjunction with CIM (common information model) that provides a common definition of management information for systems, networks, applications and services, and allows for vendor extensions. CIM's common definitions enable vendors to exchange semantically rich management information between systems in the network (see http://www.dmtf.org/standards/cim/). Some of the key benefits associated with CIM are: Common and versatile model for all information within the system, Expressive in nature, Captures quite a bit of semantic, Consistent naming scheme that provides global uniqueness, Powerful operations set both within the model and within the model manager and last but not the least Adaptable to many protocol types

Based on DMTF (distributed management task force) CIM is comprised of a Specification and a Schema. The Schema provides the actual model descriptions, while the Specification defines the details for integration with other management models.

The latest version of the Schema, CIM 2.8, provides new classes for storage and also offers modeling for the Java™ 2 Enterprise Edition (J2EE) environment. It also introduces the concept of management profiles, provides support for managing security principals and describing their authentication policy and privileges, manages IPsec policy and resulting security associations, and features modeling of the management infrastructure for discovery. One can view CIM as an example of MDA concepts and principles for the management information for systems/networks.

This generic CIM (common information model) approach can be extended beyond traditional management information (MIB/SNMP) and leveraged for the integration of information between common services – CSM (common services model) (what is also known as pervasive services) such as – DRM services (digital rights management services), LBS (location based services), AAA (authentication, authorization and access control services), etc. For example a CIM was defined for user profile data for IP based Multimedia Systems by 3GPP (3G Partnership Program), called GUP (Generic User Profile). The data model behind GUP adheres to the specifications and standards proposed by the Liberty Alliance, for Web Service – Identity Personal Profile –ID-PP (through alignment and mapping). This data model behind a user's personal profile can also be thought of as a Common Information Model.

In Service Oriented Architectures (SOA), an Enterprise's Architecture is developed in a Service Driven approach, where each service is considered to be a Service Building Block (SBB). A SBB by definition is reusable and replaceable, that is, one SBB's service is reused again and again by other services for the functionality it provides and SBB's service (vendor implementation) can be replaced by another (another vendors implementation). In SOA – the SBB's themselves can be categorized into basic/foundation services, management services, security services, business services, portal services, etc. As stated earlier the notion of a CIM can be extended to CSIM (common services information model) in support of a CSM (a common services model). It should also be noted that a SBB is offering a specific functionality for an Enterprise and transcends projects, i.e., a DRM Service as a SBB is only implemented once in an enterprise architecture and can be reused across projects that deal with delivering content, services, multi-media, etc.

To a certain extent this approach of defining Common Information Model in support of Service Building Blocks will ensure more seamless Enterprise Information Integration. It should also be noted that taking the MDA and SOA approach one can ensure ease-of future lifecycle upgrades as specific SBB can be upgraded as needed without impacting an entire architecture.

In this paper the authors attempts to highlight the significance and value-proposition of MDA for SOA, via different perspectives and examples.

Value Proposition of Meta-Models/Meta-Data (MDA) for Services (SOA):

There are five perspectives from which Meta-models and meta-data add value to services, and they are;

- Grouping, interlinking and coupling services (brokered services)
- Integrating services implemented with multiple underlying technologies
- Building value-added data driven services
- Delivering context sensitive and profile driven services
- Total Business Integration (end 2 end STP)

Grouping, interlinking and coupling services

One of the fundamental value-proposition meta-data and meta-models for a service-oriented architecture is the capability to inter-link and couple services seamlessly, through a Service Brokering solution. This is possible in environments that have Common Systems Architecture (such as an environments based on J2EE™) or ones where there is multiple common systems architecture. The service-metadata/meta model element is the representation of the common service building blocks in an environment (SBB) such as location, presence, video, etc., (this includes modeling what functionality and how it executes), and the Service Broker can essentially group, inter-link and couple these services without interfering with the inner-working s of these services. There are multiple Service Broker implementations in the market toady as well as multiple SBB that meets specific industry requirements. For example for the Telecommunications industry there are multiple vendors who have implemented LBS as a SBB and for the Airline Industry there are multiple vendors who have implemented Flight-status tracking systems as a SBB.

Grouping and interlinking these services in a seamless manner enables the delivery of advanced converged services (voice, data and video) to consumers, such as a context driven instant messaging services based on the show web-cast to an IP device. Here, the SBB and the messages they interact with in the service broker (service meta data) need to be modeled from a systems approach as the public interface defines the reusability of the SBB outside of a single project scope.

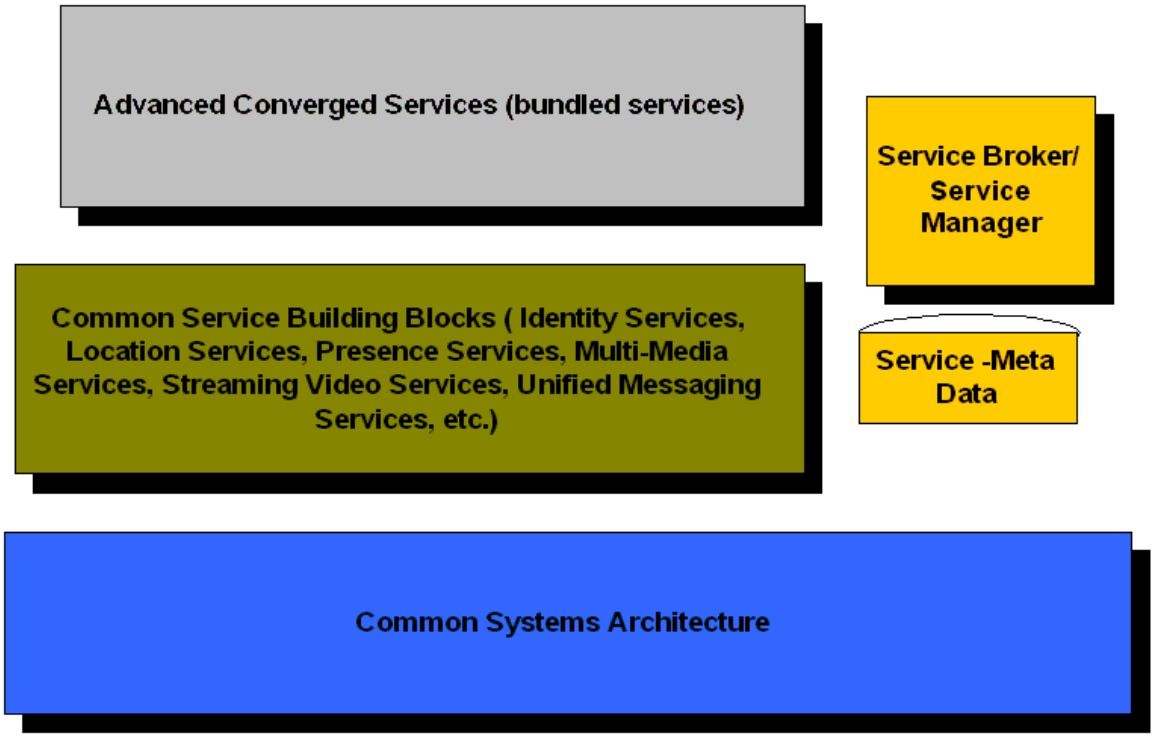

Figure 1: Service Meta Data

Integrating services implemented with multiple underlying technologies

Majority of the enterprises in all industries (health insurance, banking, retail, etc.) are moving towards a common systems architecture (based on the platform independent model that J2EE™ offers). However there are many enterprises with implementation of services based on differing underlying systems architectures (such as .NET and J2EE). MDA adds great value here with its PIM (platform independent model) that maps PSM (platform specific models) to application interfaces, code, GUI, descriptors, SQL, etc. With PIM as the – Services Meta-Data (see figure 1) it will be possible for Service Brokers not only to group and inter-link services built as SBB from a common systems architecture, however it will be possible to do the same for SBB built with varying systems architectures. What will remain a challenge is to ensure that these interlinked services can continue meeting SLA (service level agreements) and OLA (operation level agreement) requirements. It is also possible to reverse engineer existing application into a model in PIM and re-deploy it as a SBB. ***Note: The PIM from OMG's MDA perspective maps to the TRM/IIIRM (Technical Reference Model) from TOGAF's SOA perspective.***

The Technologies behind MDA helps translate high-level models to an entire IT infrastructure, instead of just translating source code to machine code. Such high-level generators covers much more ground (across platforms that includes middleware, application servers and the underlying hardware platform) than source code compilers. This essentially allows for the creation of services, SBB's and a SOA that is decoupled from the lower level platforms and infrastructures.

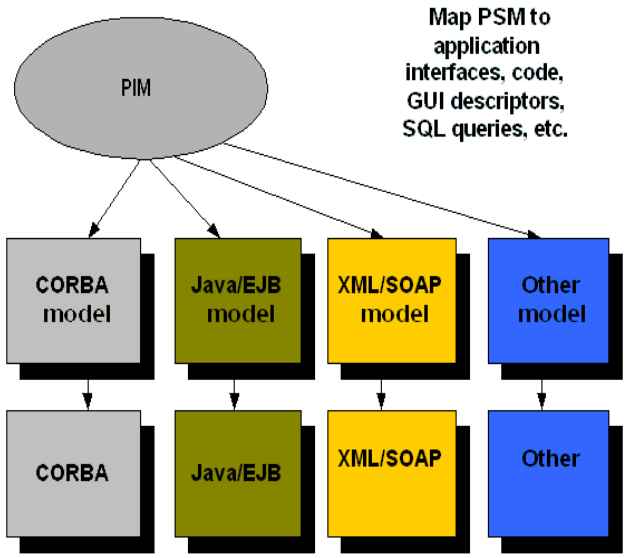

Figure 2: PIM (platform independent model)

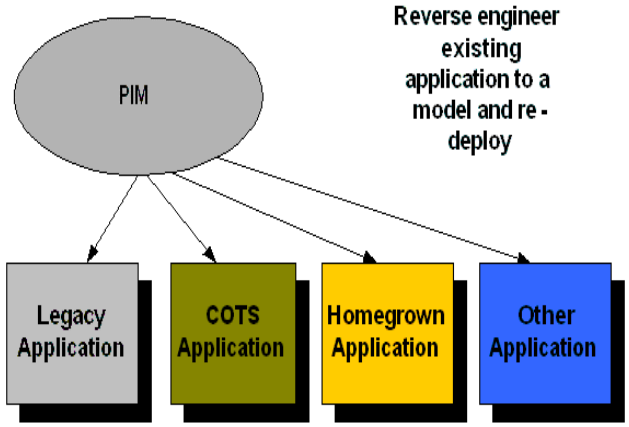

Figure 3: PIM and Reverse Engineering

Building value-added data/information driven services

In this highly competitive economic environment every business enterprise's competitive value comes from offering value-added (data sensitive) services to its customers, partners and employees. Meta-data and Meta modeling offer enormous value to these enterprises to build these value added services – services that could change very week or every day – higher-level business and or advanced converged service that leverage SBB's extensively.

Take for example the wireless carrier space – customer's value having the latest information in there handheld. Offering a data-sensitive value added services such as peak-time usage that day (after 5:00pm) can be viewed by the customer by pressing *9999 is considered to be extremely valuable to customers who want to keep track of there usage in accordance with there peak-time allowed usage.

In the airline industry it's now a common practice to deliver messages (IM, SMS, email, web-mail, voicemail, etc.) by any customer specific means about delays in flights. There are other employee/executive facing data sensitive services around performance, business intelligence, etc., that's also real-time (Business Activity Management) that is derived from a meta-data/meta model repository (such as a the CWM) that allows for data mining and real-time queries (queries against both transactional and transient data) against database boundaries. The techniques put in use using MDA is paving the way to help develop and deliver these data sensitive services –on demand and close to real-time. Majority of these data sensitive services – customer facing, employee facing or supplier facing comes from information retrieved with BI tools (+ BPM and BAM tools) sitting on top of data ware houses and data marts as well as a repository such as CWM+MOF. ***The CWM+MOF+XMI from OMG's MDA perspective maps to the IIIRM (Integrated Information Infrastructure Reference Model) from TOGAF's SOA perspective.***

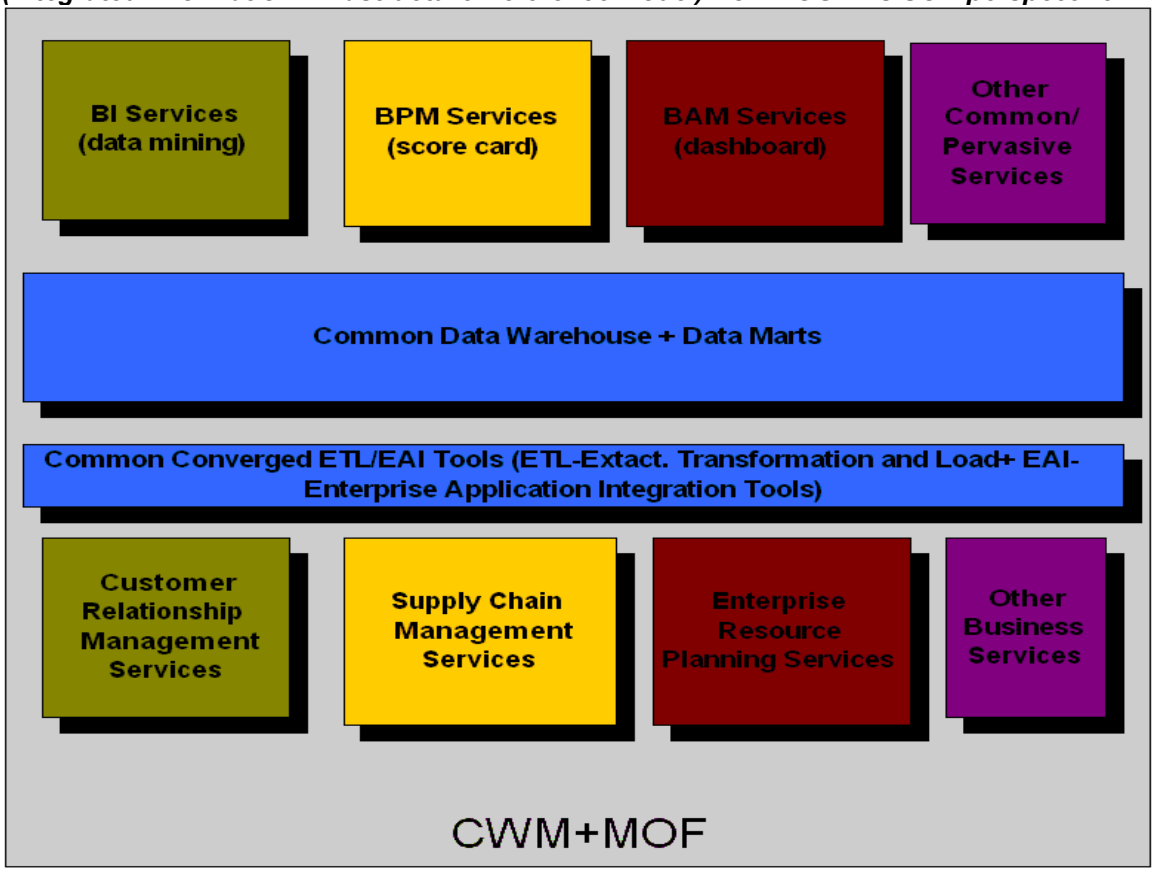

Figure 4: A common warehouse model with meta-object facility and XMI

Delivering context sensitive and profile driven services

Another major challenge to delivering Services based Service Oriented Architectures is adding context sensitivity and user profile centricity to these services.

Major strides are being made in this space with the DMTF efforts towards a Common Information Model for Management information. The notion of both Directory Enabled Networks (DEN) and Identity Enabled Networks (IDEN) also come into play here. The Identity/Directory Enabled Network (DEN and IDEN) initiative is designed to provide the building blocks for more intelligent management by mapping concepts from CIM (such as systems, services and policies) to a directory (a highly distributed database), and integrating this information with other elements in the management infrastructure. This utilizes existing user and enterprise-wide data already present in a company's directory, empowers end-to-end services, and supports distributed network-wide service creation, provisioning and management. Common schema and semantics are especially important when defining and decomposing platform-neutral, high-level policies. Integration within the infrastructure ties high-level, infrequently changing directory data to the other, more real-time components of the management infrastructure. The goal here is to use a directory as follows: first to "direct" clients to relevant management services, and second, to hold a subset of management data. This includes;

- *Common identity and security administration*
- *Common understanding of managed systems and services*
- *Information related to locations, groupings and policy*
- *Information related to presence*

Treating this IDEN initiative as meta-data and meta-model – more advanced context sensitive and profile driven services can be delivered using identity, location, presence and related management services as SBB. A good example of such a service is: Delivering a weather report at 7:00 am every morning to your handheld device (based on your profile requesting such a service) – based on your location (lets say Ashburn, Virginia) and presence. It should also be noted that Meta-exchange facilities (such as a meta-directory) is heavily used to map to the actual sources of data (such as File Systems, DBMS, RADIUS, flat files, NIS+, etc.) with information/model that has explicit details around the schema of these data and workflow associated with how these sources are kept in sync with an IDEN.

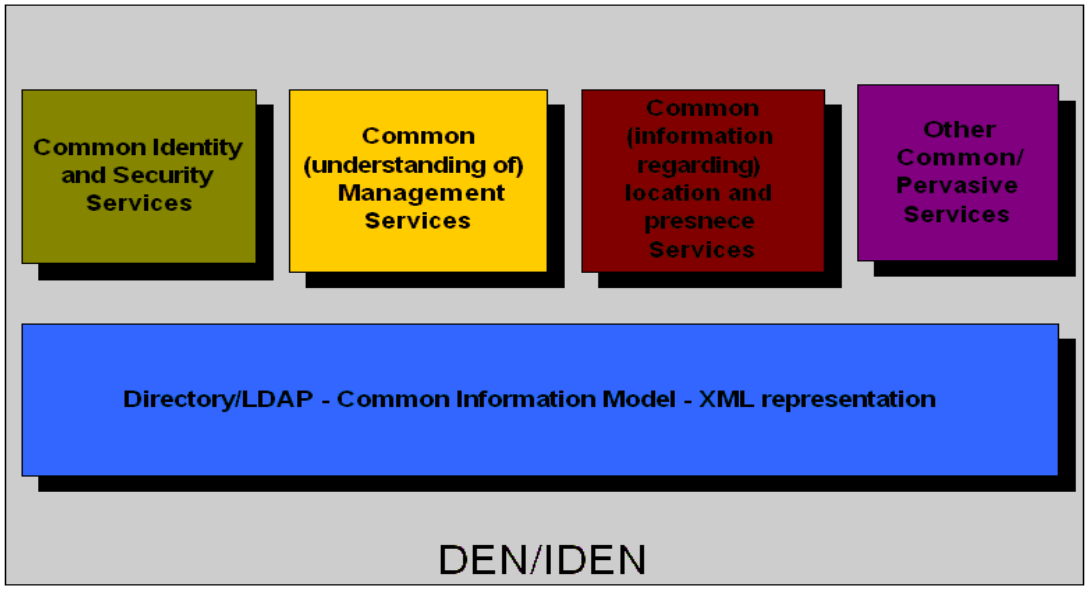

Figure 5: Directory and Identity enabled Networks offering a Common Information Model

Total Business Integration and end2end Straight Through Processing (STP)

If an Enterprise embraces all the four areas discussed in this paper;

Grouping, interlinking and coupling services (brokered SBB) with Service-Metadata/meta-model and a Service Broker, Integrating services implemented with multiple underlying technologies using Platform Independent Models (the services-meta-data/meta-model has to be platform independent), Building value-added data driven services with CWM/MOF (extending the PIM to support CWM as well as MOF/XMI), and Delivering context sensitive and profile driven services leveraging a DEN/IDEN (directory/identity enabled network), then the Enterprise (Technology) Architecture is set to achieve Total Business Integration that uses end-to-end integration with straight through processing. All 4 approaches leads to this strategic benefit associated with MDA enabling SOA, especially in a web services world. There are multiple dimensions that lead to STP in a totally integrated business environment;

- *Standards based (web services based-XML) integration for both B2B Integration and EAI integration and for Converged Services (voice, data and video)*
- *Convergence of ETL and EAI to a Common Integration Services Bus (CISB) (that supports multiple connection models, session management models, transaction models and messaging models).*
- *State Data Repository (in conjunction with a CISB a common state repository is maintained to capture the state associated with Connection (user connection and inter-service connections), Session (user session and service sessions), Transactions and Messages (including transactional-messaging) to ensure STP.*
- *Common Services Information Model (distributed Data Models are normalized to Services that require inter-linking – simply put a LBS implementation has all location specific data that other services require – no redundancy of location service data residing as part of another service)*
- *Common QOS model (a meta-model that captures QOS data in conjunction with the SLA per service)*

This STP as a technique acts as a solution that automates the end to end processing of transactions (financial transactions) for all financial instruments from initialization to resolution. STP although intended for financial transaction services, can be applied across all business processes (to address settlement, auditing, non-repudiation, etc). STP can be achieved and applied to SCM services as well as CRM services that involve multiple entities and enterprises. It can be network agnostic, device agnostic, service agnostic, domain agnostic and platform agnostic. However it requires a set of “Architectural Technologies” to support it.

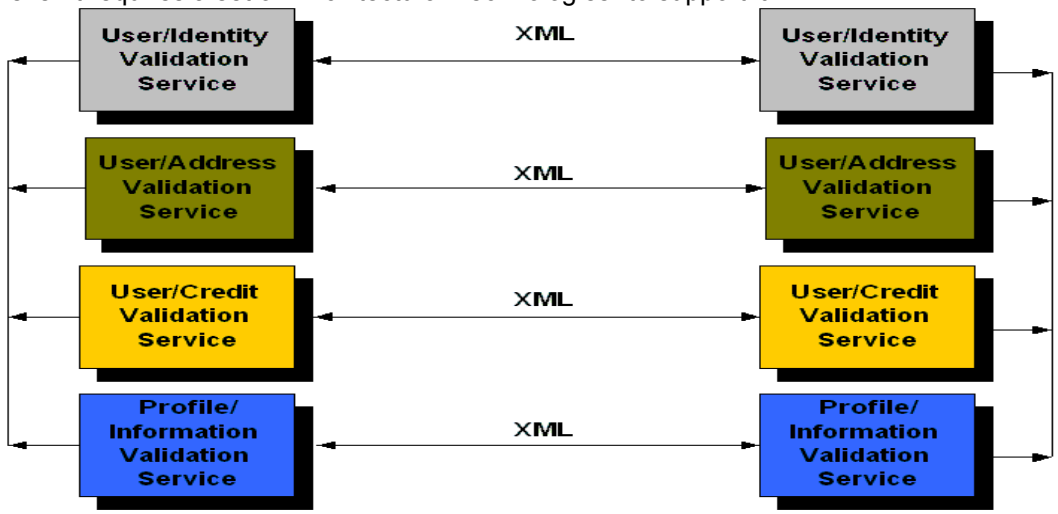

Figure 5: STP

Conclusion

End-to-End Java Technologies (the combination making it an ***"Architectural Technology"***) ensures that MDA enabled SOA's are possible and all the five benefits associated with the same are achievable.

Java's support includes many open standards body, standards forum's and industry initiative's such as OMG's MDA initiative (CWM, MOF, XMI, etc.), TOG's SOA initiative (ADM, TRM, IIRM, etc.), DMTF initiatives around (DEN/IDEN and CIM), ISO initiatives around XML based STP, NIST initiative around JAIN/SIP, and more to delivery (IP/packet) network centric solutions that offer services that are device independent, location independent, access network independent, service independent, domain independent and platform independent, however they are profile-driven and context-sensitive to address end users needs. In fact Java has been the inspiration for the initiation and implementation of many of these initiatives.

Additional ancillary standards such as, RFID, CDC/CLDC, MIDP, LDAP, XML, SOAP and Http/Http-s are all supported in these Java Technologies.

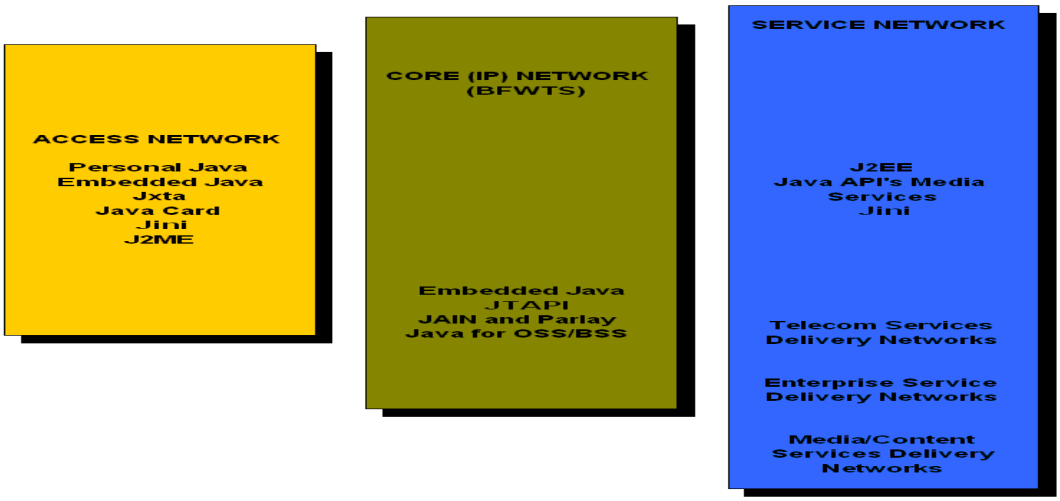

Figure 6: Java Technologies

These Java Technologies work in conjunction with IP initiatives such as MobileIP and IPSec as well as XML technologies including SAML and XKMS.

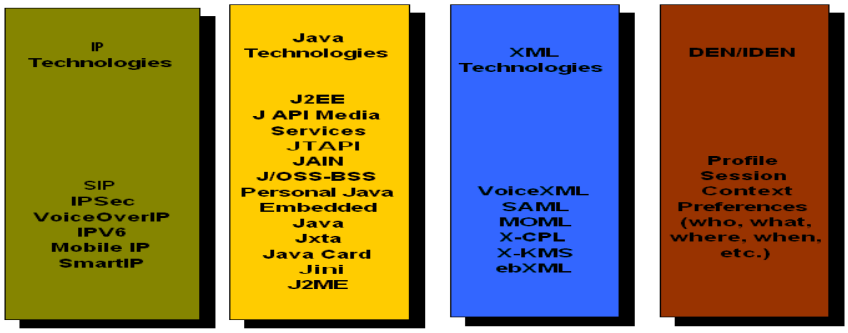

Figure 7: IP, Java, XML and IDEN

In conjunction with the convergence of voice, data, and video services, convergence of networks (PSTN, IP, 3G, Cable, etc.), one key convergence that is made possible with MDA+SOA is the notion of Converged Architectures – where Business and IT Architectures are defined, designed, developed and deployed as one and the same. Richard Hubert the author of "Convergent Architecture – Building Model Driven J2EE Systems with UML" talks to this notion of how "services/applications" that support business models and IT models (around SLA, QOS and metrics for the management/delivery and support of these business services) can be united to ensure appropriate alignment of Business to IT. Meta-data, meta-models and the modeling that goes behind these services help ensure this alignment.

It should be noted that many of these techniques are being embedded as implementations within the next generation network. Capabilities such as model/meta-data driven Service Provisioning (N1SPS –formerly Center Run), MOF/CWM embedded within Storage Processors in a Storage Network (3Par), PIM based Architecture Maintenance (Met Matrix), IDEN platforms (such as JES Identity Server/Oblix), that customers can implement as Building Blocks in their Architecture.