Driving MDA with UML: Principles and Practices

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Who am I?

- Research fellow, UC Irvine (2000–)
  - biologically-inspired software designs for scalable and adaptable distributed computing
- Ph.D. from Keio U (2001)
- ex- Technical director, Object Management Group Japan
- ex.ex- Technical director, Soken Planning Co., Ltd.

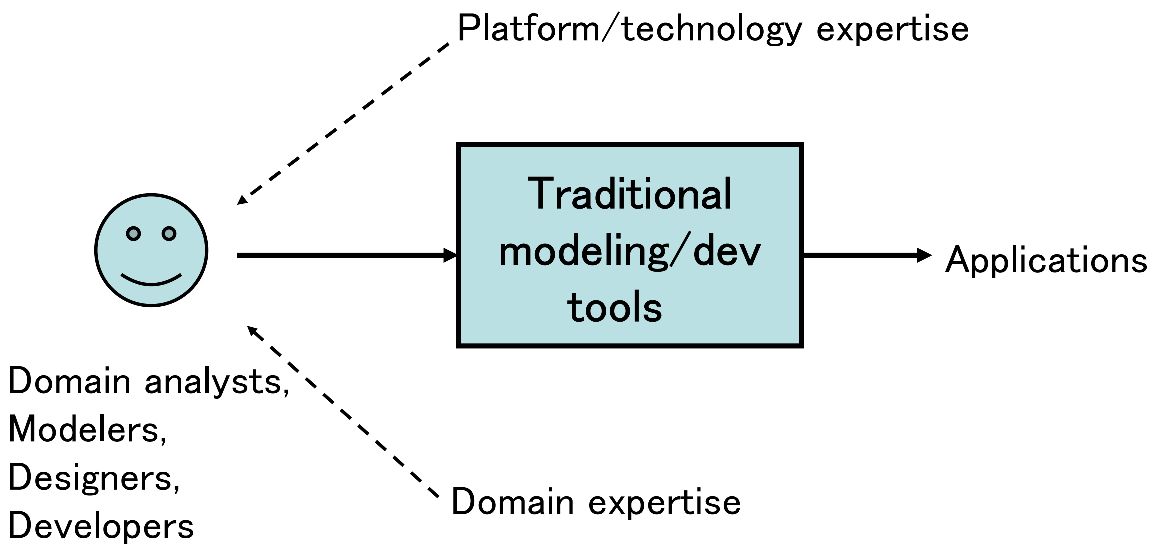
Where is UC Irvine?

- UCI (U of California, Irvine)
  - One of eight UC system universities
- Irvine
  - in between LA and San Diego
  - reported by FBI, as the safest city in the US
  - 1 hour to LA downtown
  - 10 minutes to Newport Beach
  - 20 minutes to Huntington Beach
  - 20 minutes to Anaheim Disneyland
  - 5 hours to Las Vegas

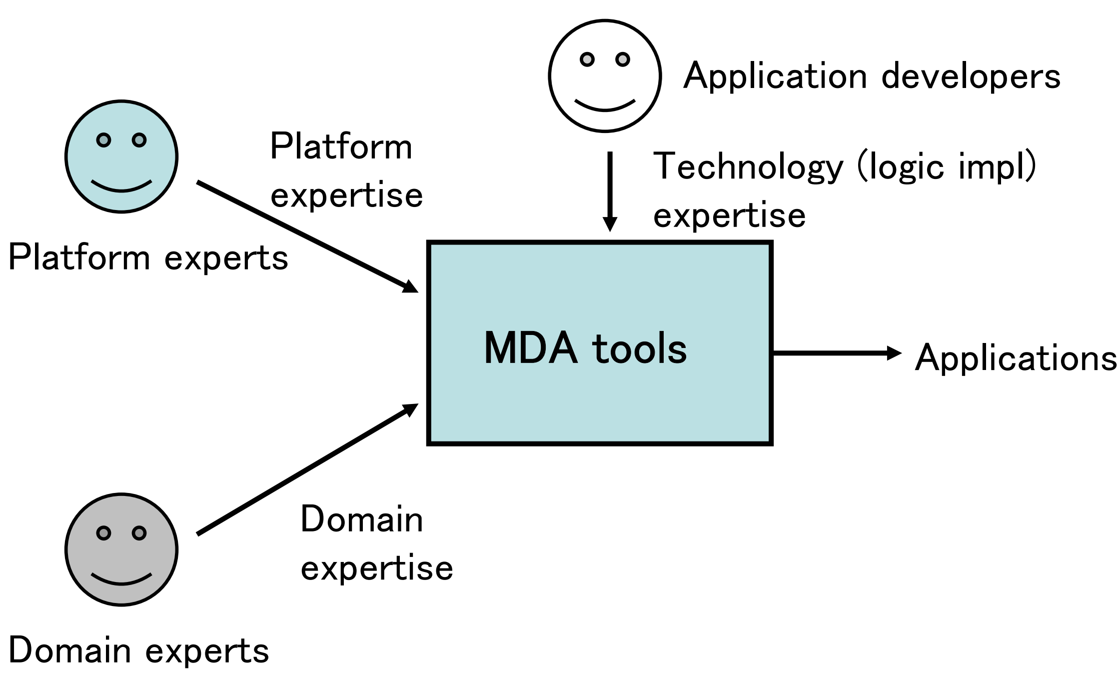
Overview

- MDA (Model Driven Architecture)
  - Model transformation and integration
    - Patterns and technologies for model transformations
- MDA Practices
  - Standardization effort based on MDA principles
    - OMG Super Distributed Objects specification
  - MDA practice for ubiquitous computing
    - Bio-Networking Architecture

Traditional Modeling and Development



MDA-based Modeling and Development



Goals in MDA

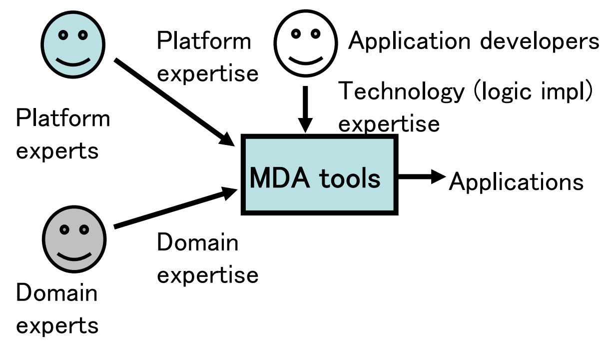
- Model continuation
  - Maximizing model continuation during software development process.
- Separation of concerns
  - Maximizing separation of concerns

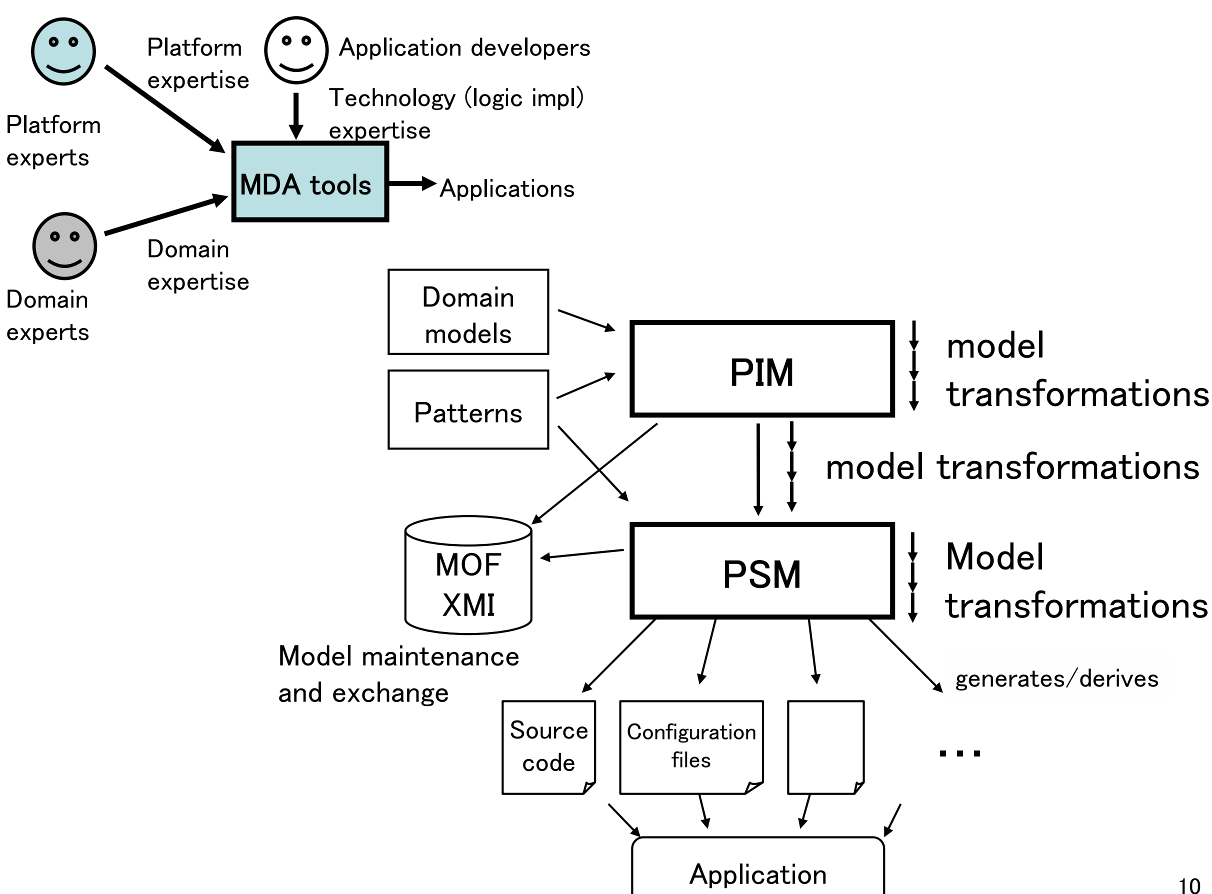
Benefits from MDA

- Reduced software development cost
- Reduced software development time
- Rapid and smooth integration of legacy and emerging technologies

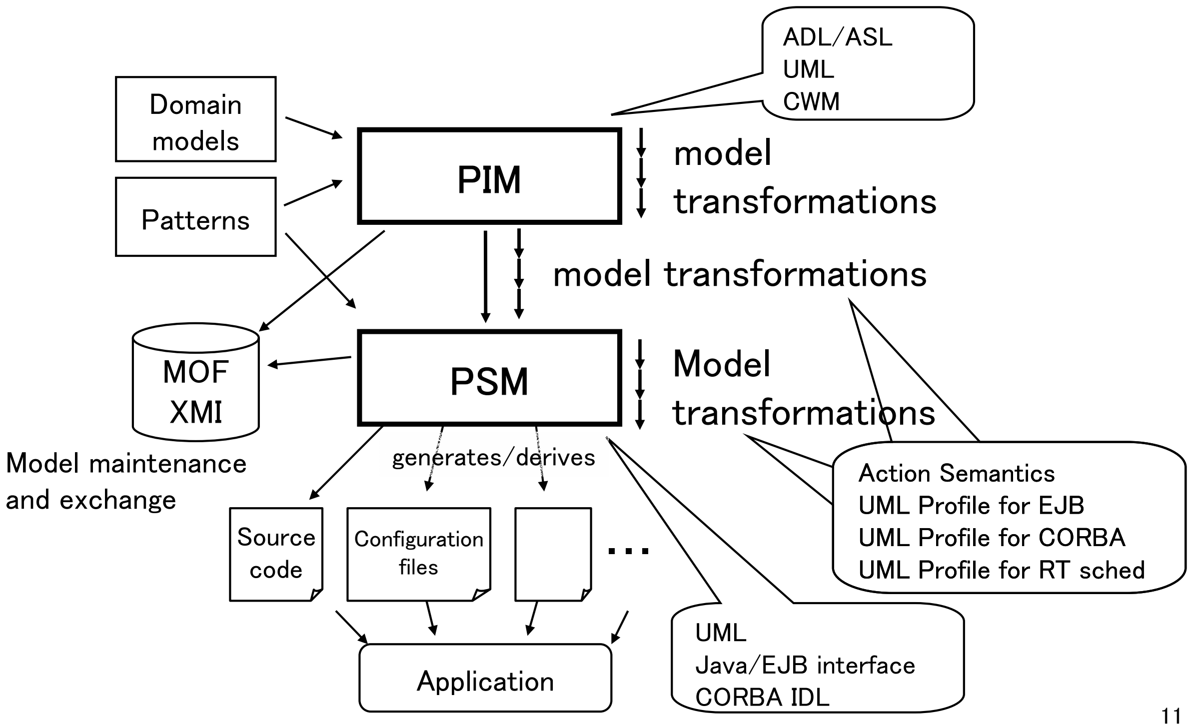
Model Transformation and Integration

- Model transformation
  - Domain specialization
  - Platform specialization
- Model integration
  - Model weaving





Model Transformation



Platform Independent Model (PIM)

- Modeled with
  - UML
  - ADL/ASL
  - Conceptual drawings
- may incorporate several software patterns
  - Architectural, analysis and design patterns

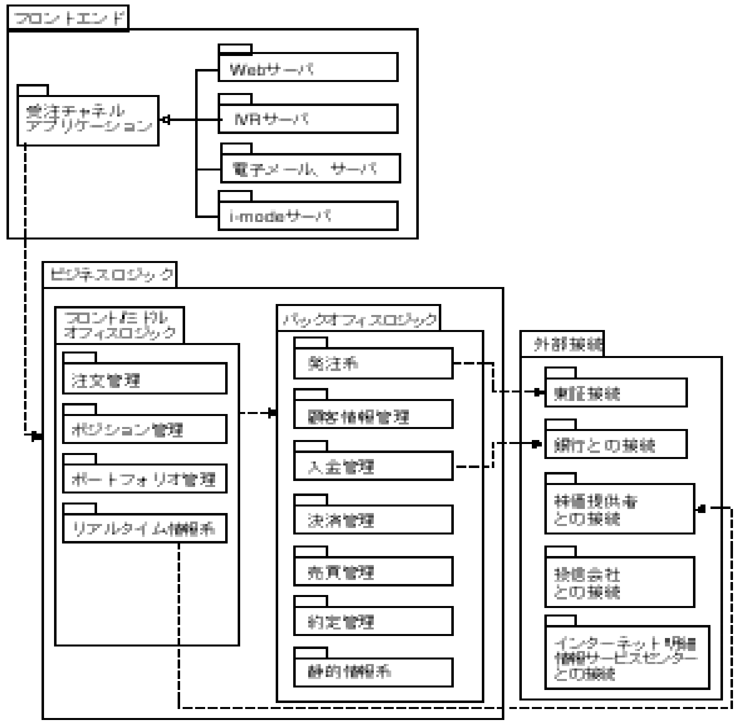
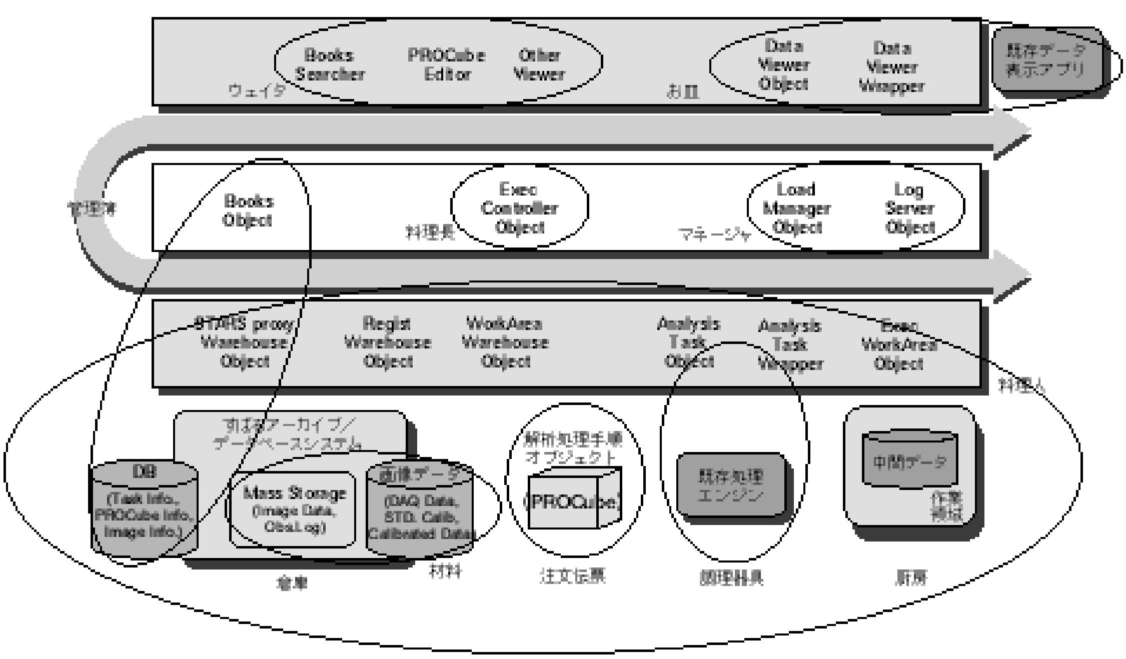
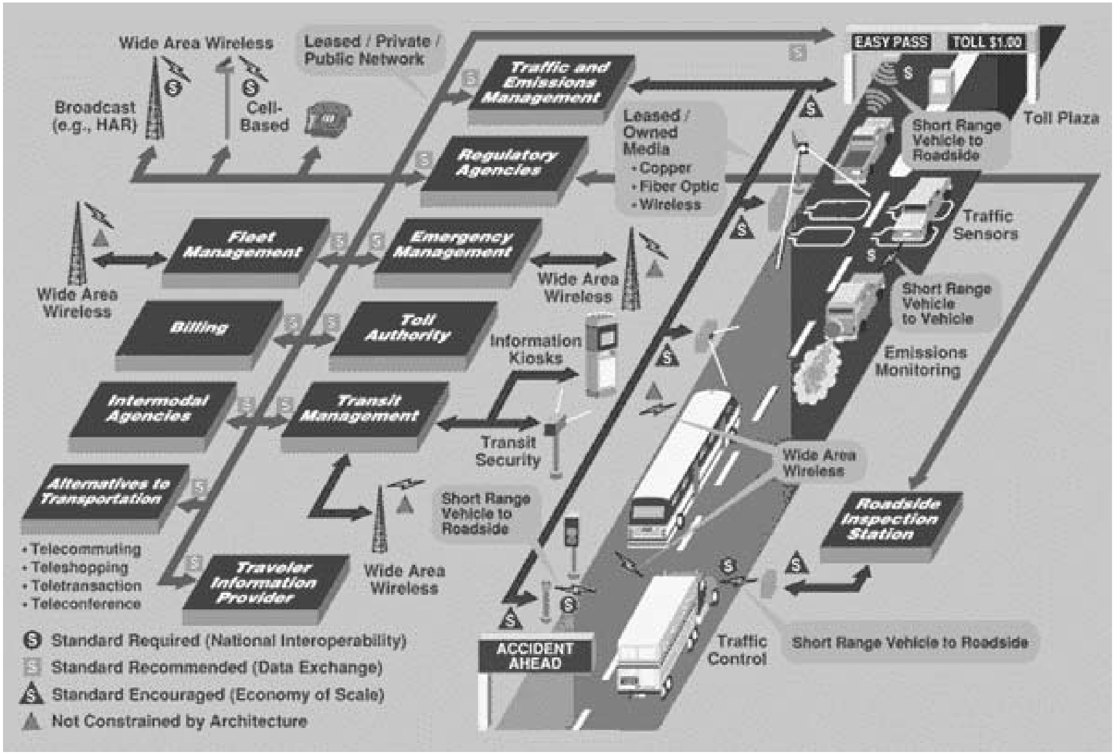
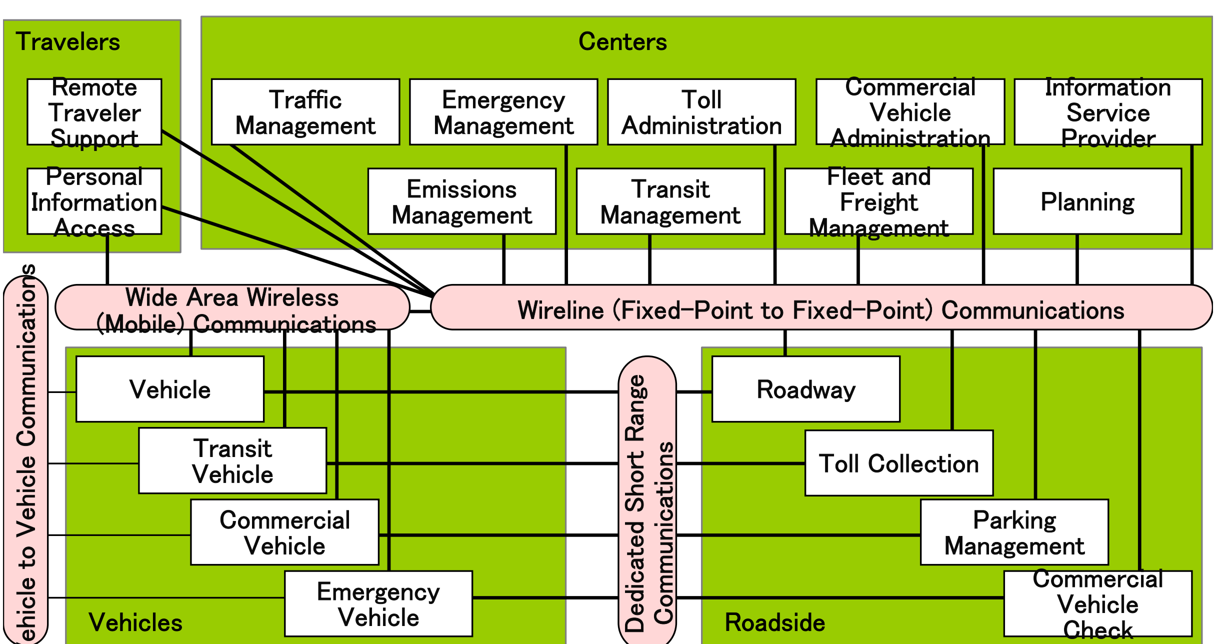
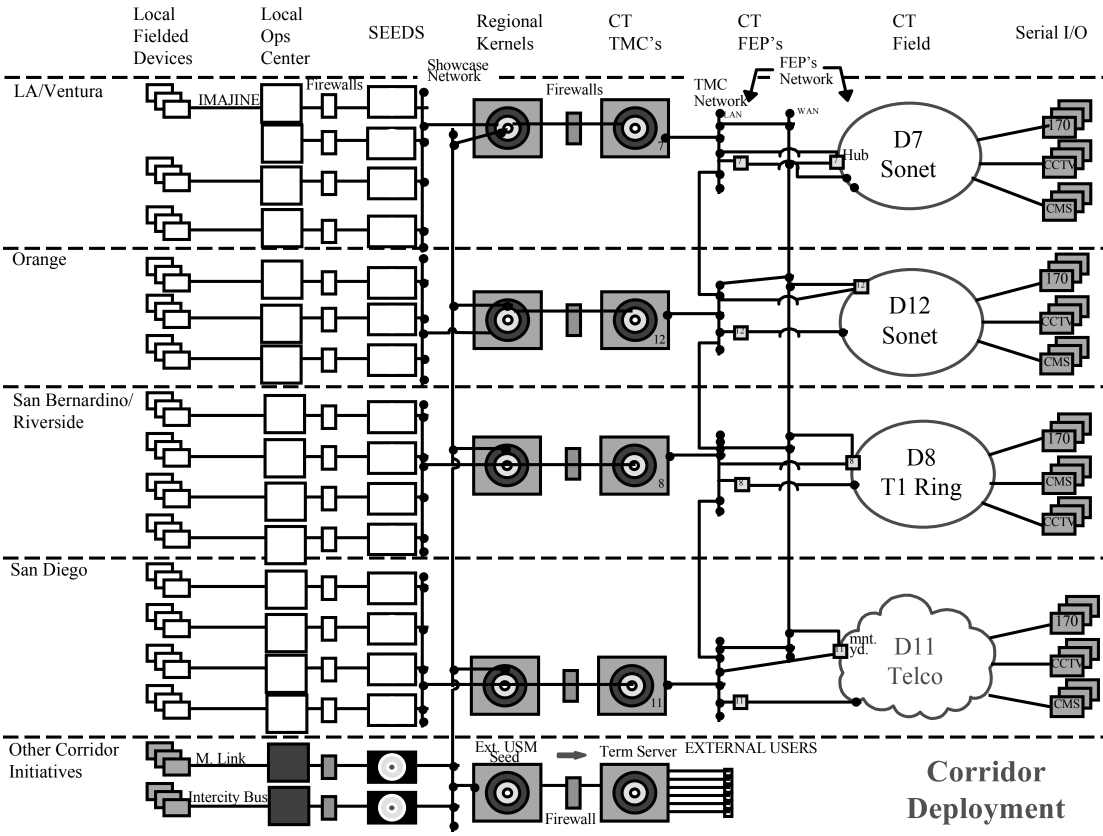


図2：DASHアプリケーション構成概念図

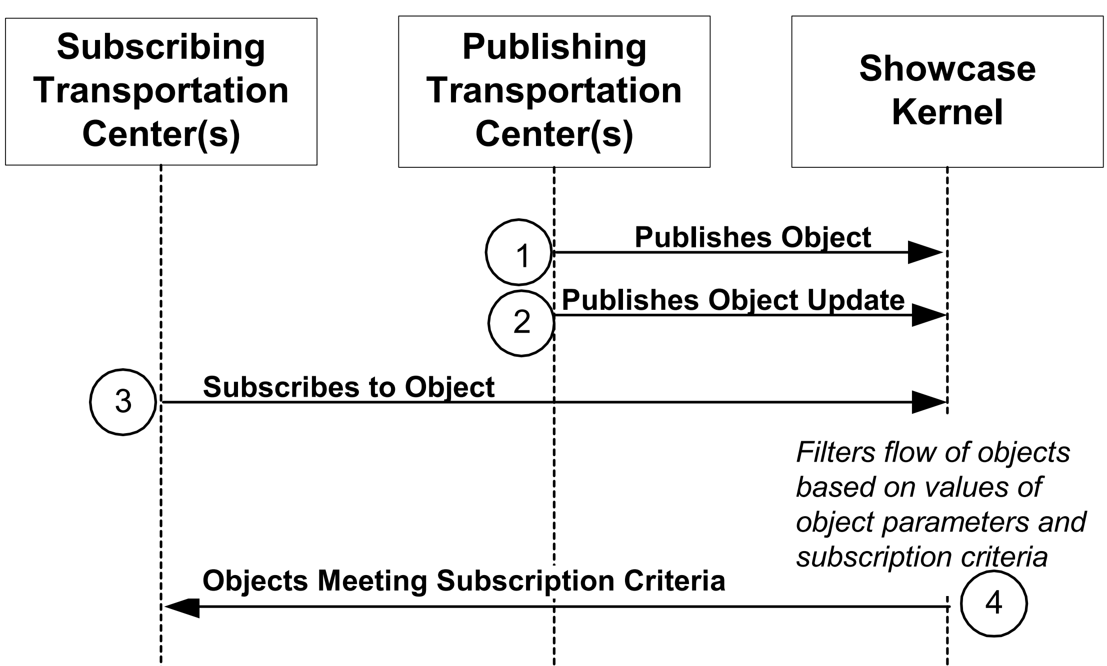



Wide Area Wireless
Leased / Private / Public Network
Broadcast (e.g., HAR)
Cell-Based
Traffic and Emissions Management
Leased / Owned Media
• Copper
• Fiber Optic
• Wireless
Regulatory Agencies
EASY PASS
TOLL $1.00
Toll Plaza
Short Range Vehicle to Roadside
Traffic Sensors
Wide Area Wireless
Fleet Management
Emergency Management
Wide Area Wireless
Billing
Toll Authority
Information Kiosks
Short Range Vehicle to Vehicle
Emissions Monitoring
Intermodal Agencies
Transit Management
Transit Security
Wide Area Wireless
Alternatives to Transportation
• Telecommuting
• Teleshopping
• Teletransaction
• Teleconference
Short Range Vehicle to Roadside
Roadside Inspection Station
Traveler Information Provider
Wide Area Wireless
ACCIDENT AHEAD
Traffic Control
Short Range Vehicle to Roadside
Standard Required (National Interoperability)
Standard Recommended (Data Exchange)
Standard Encouraged (Economy of Scale)
Not Constrained by Architecture

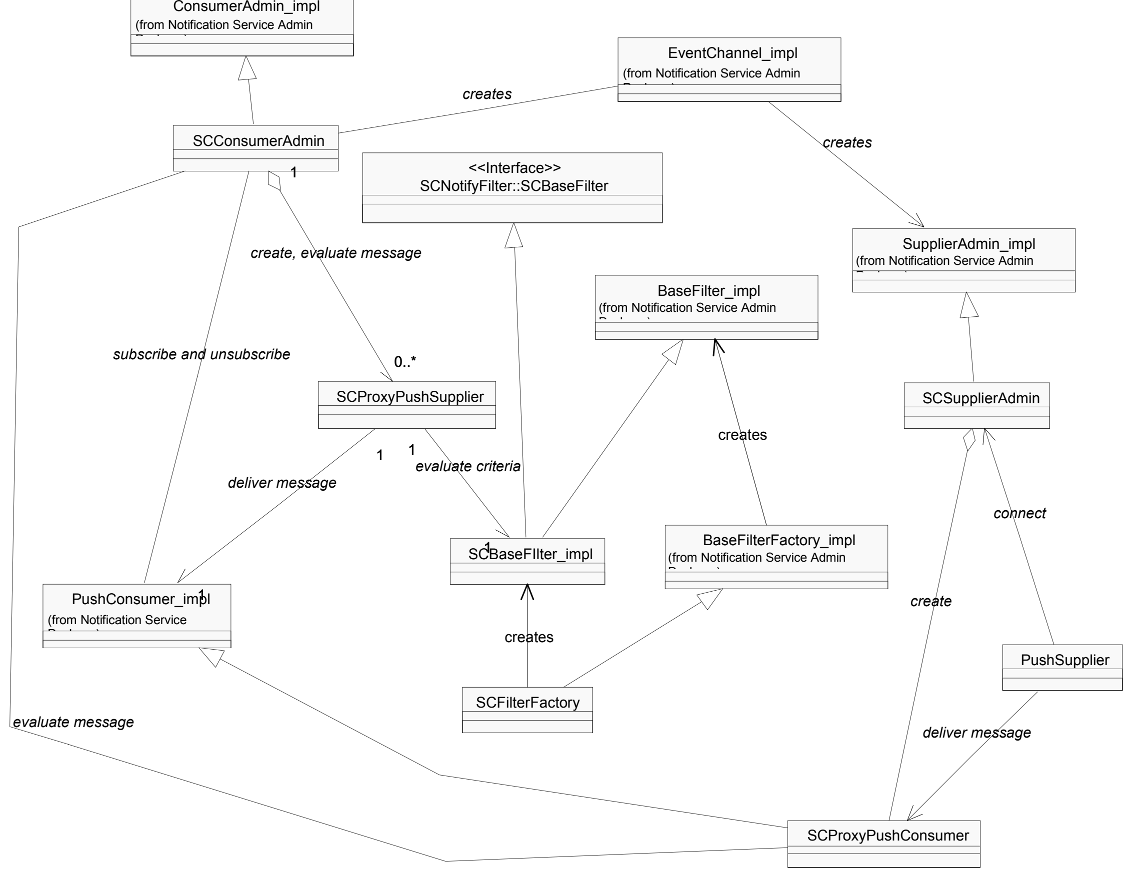

Travelers
Remote Traveler Support
Personal Information Access
Centers
Traffic Management
Emergency Management
Toll Administration
Commercial Vehicle Administration
Information Service Provider
Emissions Management
Transit Management
Fleet and Freight Management
Planning
Wide Area Wireless (Mobile) Communications
Wireline (Fixed–Point to Fixed–Point) Communications
Vehicle to Vehicle Communications
Vehicle
Transit Vehicle
Commercial Vehicle
Emergency Vehicle
Vehicles
Dedicated Short Range Communications
Roadway
Toll Collection
Parking Management
Commercial Vehicle Check
Roadside


Local Fielded Devices
Local Ops Center
SEEDS
Regional Kernels
CT TMC's
CT FEP's
CT Field
Serial I/O
Showcase Network
Firewalls
TMC Network
FEP's Network
LAN
WAN
LA/Ventura
IMAJINE
Hub
D7 Sonet
Orange
D12 Sonet
San Bernardino/ Riverside
D8 T1 Ring
San Diego
mnt. yd.
D11 Telco
170
CCTV
CMS
Other Corridor Initiatives
M. Link
Intercity Bus
Ext. USM Seed
Term Server
EXTERNAL USERS
Firewall
Corridor Deployment

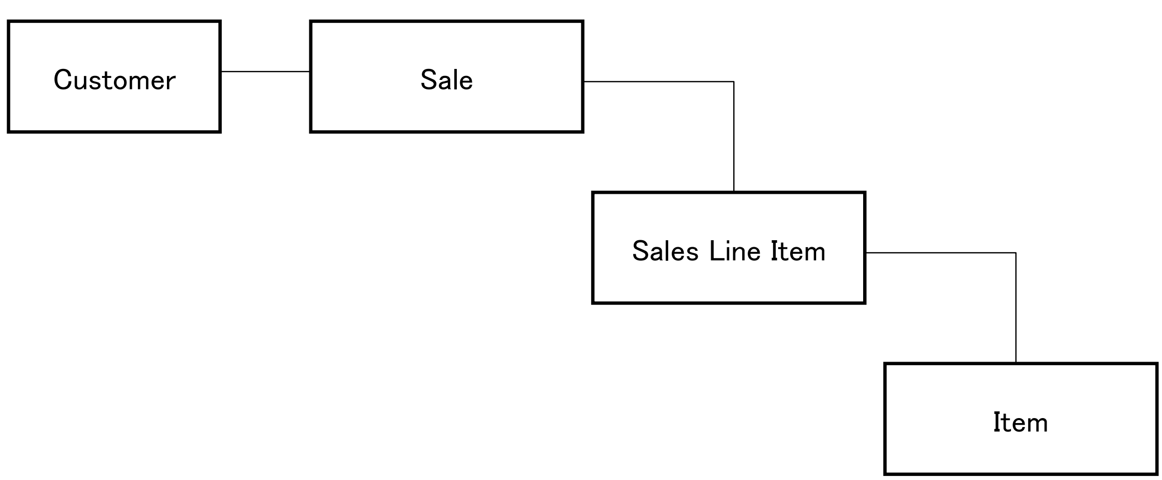
17


Subscribing Transportation Center(s)
Publishing Transportation Center(s)
Showcase Kernel
1
Publishes Object
2
Publishes Object Update
3
Subscribes to Object
Filters flow of objects based on values of object parameters and subscription criteria
Objects Meeting Subscription Criteria
4

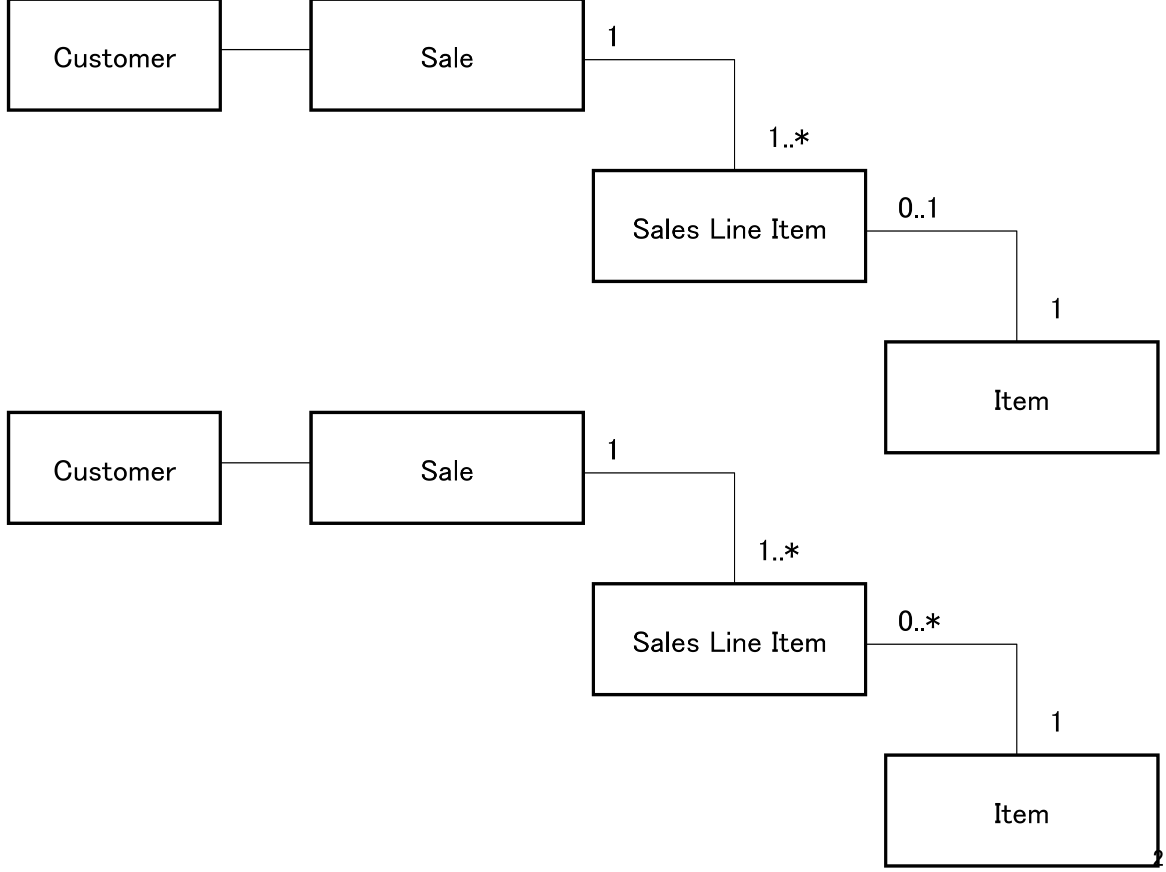
18


ConsumerAdmin_impl
(from Notification Service Admin
EventChannel_impl
(from Notification Service Admin
creates
SCConsumerAdmin
creates
1
<<Interface>>
SCNotifyFilter::SCBaseFilter
SupplierAdmin_impl
(from Notification Service Admin
create, evaluate message
BaseFilter_impl
(from Notification Service Admin
subscribe and unsubscribe
0..*
SCProxyPushSupplier
SCSupplierAdmin
1
1
evaluate criteria
creates
deliver message
connect
SCBaseFIlter_impl
BaseFilterFactory_impl
(from Notification Service Admin
PushConsumer_impl
(from Notification Service
create
creates
PushSupplier
SCFilterFactory
evaluate message
deliver message
SCProxyPushConsumer

19

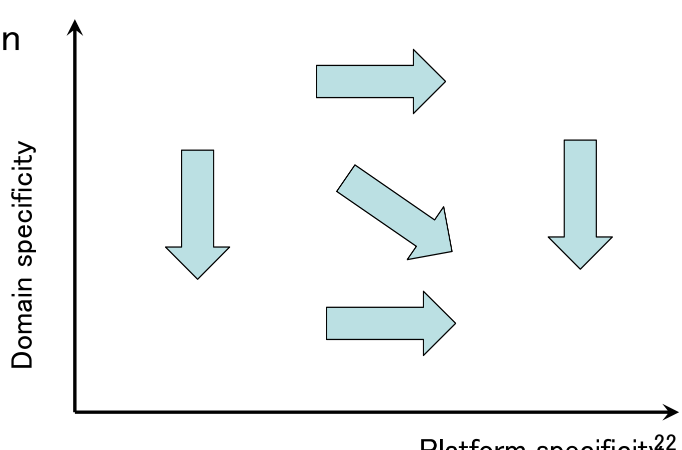

Customer
Sale
Sales Line Item
Item

20



Model Transformation

- 2 dimensions of model transformation
  - Domain specialization
  - Platform specialization
- Several forms of model transformation
  - Manual transformation
  - Automatic transformation



Technologies for Model Transformations

- UML profiles
  - for EJB
  - for CORBA
  - for Realtime scheduling
- Action semantics
  - allows modelers to embed actions (behaviors) into model elements.

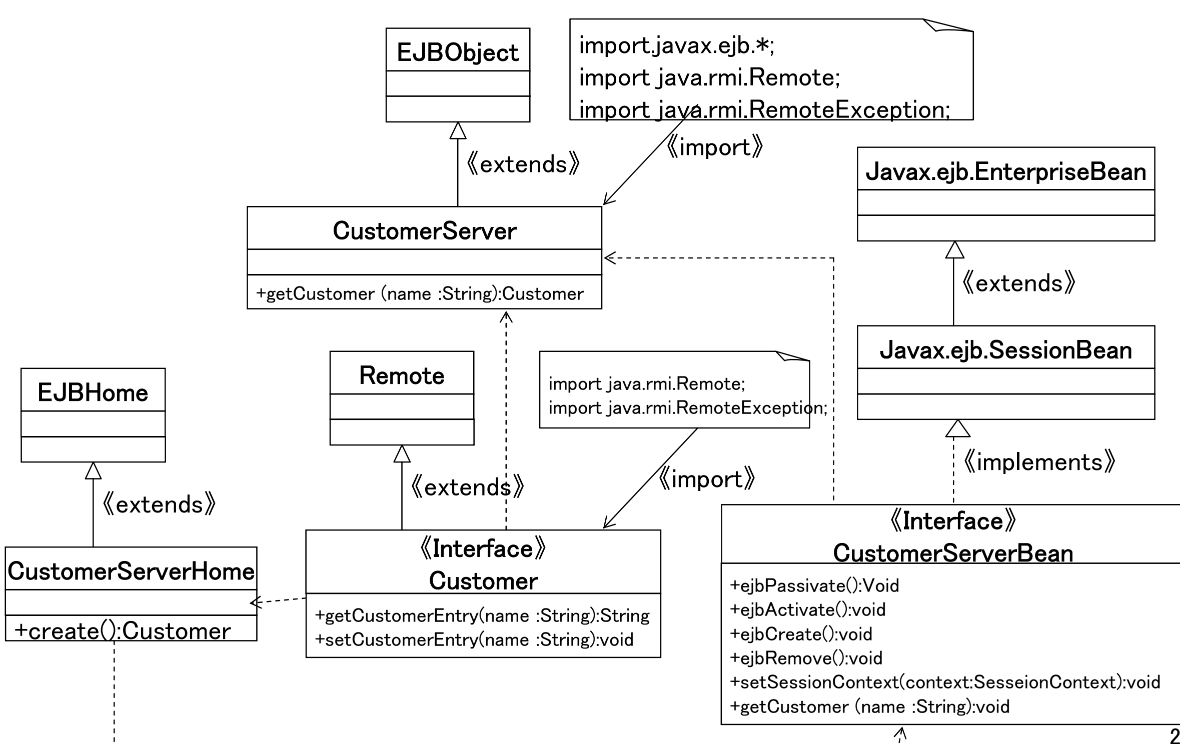
UML Profiles

- A UML profile
  - provides a means to specialize UML models to a specific domain or implementation technology.
  - is defined with the UML extension mechanism
    - i.e. stereotypes, tag definition/tagged values, and constraints
  - may extend the UML standard meta model.
    - Virtual meta model

UML Profile for EJB

- http://jcp.org/jsr/detail/26.jsp

《JavaInterface》	Java interface
《EJBHomeInterface》	Home interface
《EJBRemoteInterface》	Remote interface
《EJBImplementation》	Implementation class of a bean
《EJBSessionBean》	Session bean
《EJBEntityBean》	Entity bean



Super Distributed Objects (SDOs)

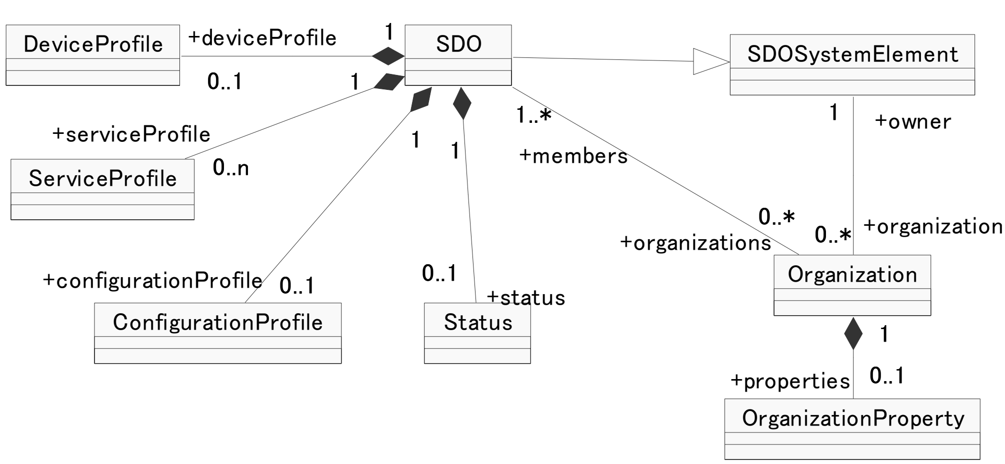
- The goals of the OMG Super Distributed Objects (SDOs) DSIG (domain SIG) are to
  - provide a standard computing infrastructure that incorporates massive number of objects (SDOs) including hardware devices and software components
  - deploy SDOs in highly-distributed and ubiquitous environments, and
  - allow SDOs to seamlessly interwork with each other in a less centralized manner.
- SDO is…
  - a logical representation of hardware devices and software components operating on highly-distributed and ubiquitous networks.

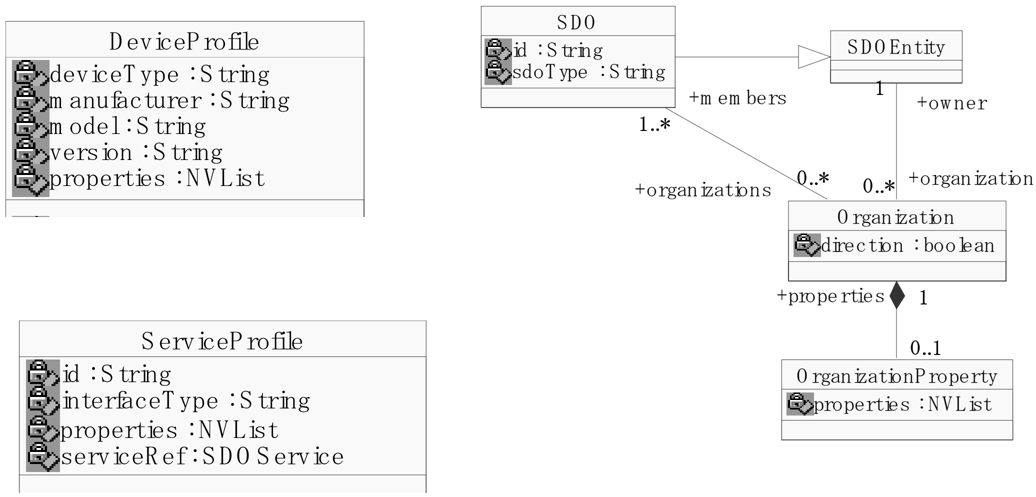
- History and status:
  - The SDO RFI issued (‘00), and responses gathered (‘01)
    - from 10 organizations including UCI
  - The SDO white paper published (‘01)
    - by Hitachi, GMD Fokus and UCI
  - The first RFP published (Jan. 02), which
    - solicits the resource data model for SDOs, and interfaces to access and manipulate resource data model.
    - sdo/02-01-04
  - The initial proposals submitted (Sept. 02)
    - by Hitachi, GMD Fokus and UCI
    - sdo/02-09-01, sdo/02-09-02
    - 28 organizations on the voting list
  - The revised joint proposal was submitted in March 2003.
    - by Hitachi, GMD Fokus and UCI
    - sdo/02-01-04
  - The submission was recommended for adoption.

SDO PIM and PSM Specification

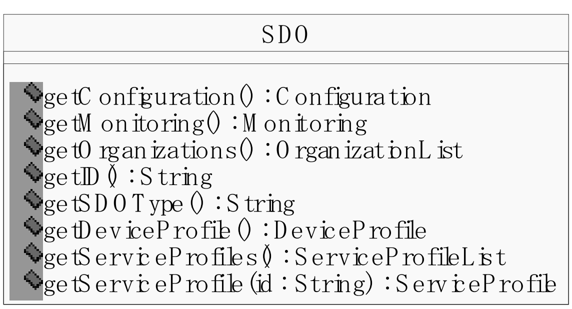
- Addresses information and computational aspects for SDOs
  - Information aspect
    - Resource data model, used to define the capabilities and properties of SDOs.
  - Computational aspect
    - A set of interfaces, used to access and manipulate resource data model.
- Defines a PIM and PSM for each of the aspects.
  - UML used to define PIM.
  - CORBA IDL used to define PSM.

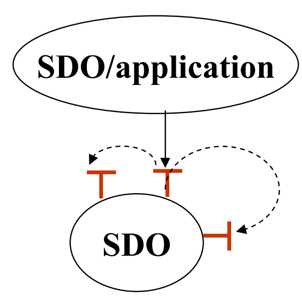
SDO Resource Data Model



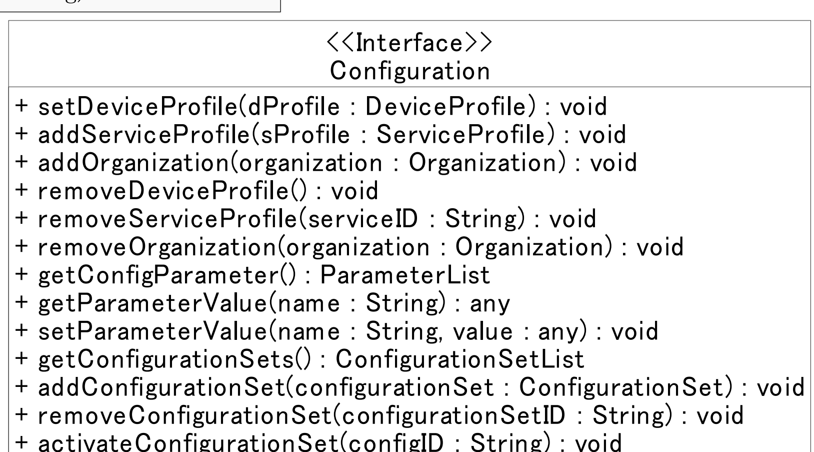


SDO Interfaces





Interfaces:
SDO
Organization
Configuration
Monitoring
Callback

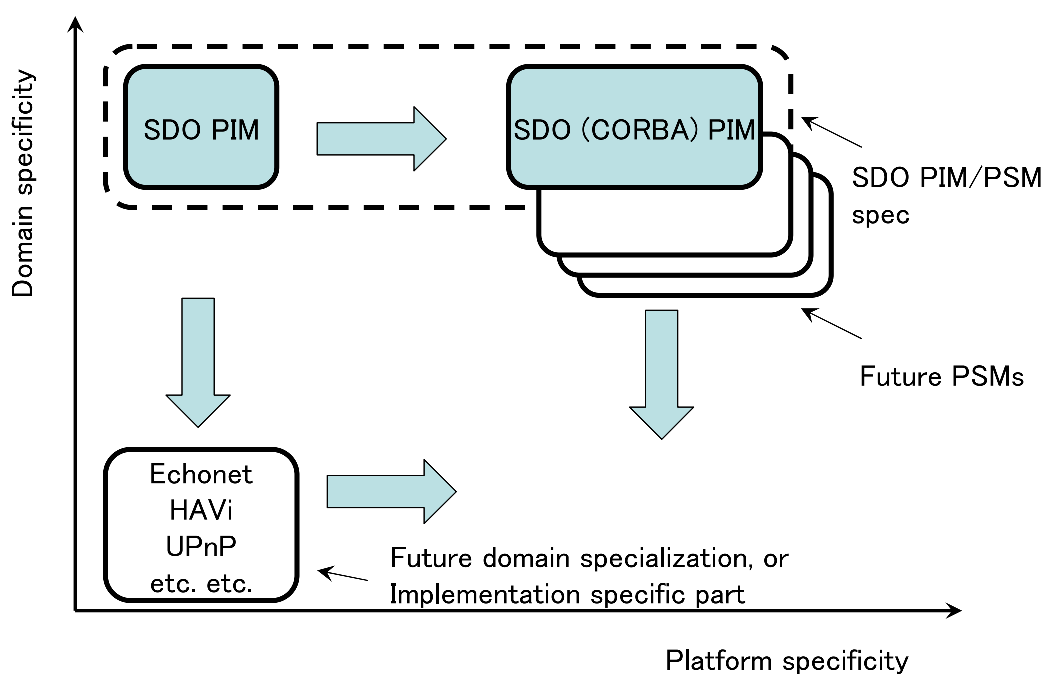


CORBA PSM

- CORBA PSM for SDO resource data model and interfaces

```
module SDOPackage {
    interface SDO;
    interface SDOService;
    interface SDOSystemElement;
    interface Configuration;
    interface Monitoring;
    interface Organization;
    interface SDO : SDOSystemElement {
        UniqueIdentifier get_id()
        string get_SDO_type()
```


Scope of SDO PIM/PSM



The Bio-Networking Architecture: An Example of SDO Implementations

- Computer network environment is seamlessly spanning locations engaged in human endeavor.
- Need a self-organizing network that supports
  - *scalability* in terms of # of objects and network nodes,
  - *adaptability* to changes in network conditions,
  - *availability/survivability* from massive failures and attacks,
  - *simplicity* to design and maintain.
- Our solution: *apply biological concepts and mechanisms to network application design*
  - Biological systems have overcome the above features.
    - e.g. bee colony, bird flock, fish school, etc.
- The Bio-Networking Architecture is a new framework
  - for developing large-scale, highly distributed, heterogeneous, and dynamic network applications.

Biological Concepts Applied

- Decentralized system organization
  - Biological systems
    - consist of autonomous entities (e.g. bees in a bee colony)
    - no centralized (leader) entity (e.g. a leader in a bird flock)
      - Decentralization increases scalability and survivability of biological systems.
  - The Bio-Networking Architecture
    - biological entities = cyber-entities (CEs)
      - the smallest component in an application
      - provides a functional service related to the application
      - autonomous with simple behaviors
        - » replication, reproduction, migration, death, etc.
        - » makes its own behavioral decision according to its own policy
    - no centralized entity among CEs

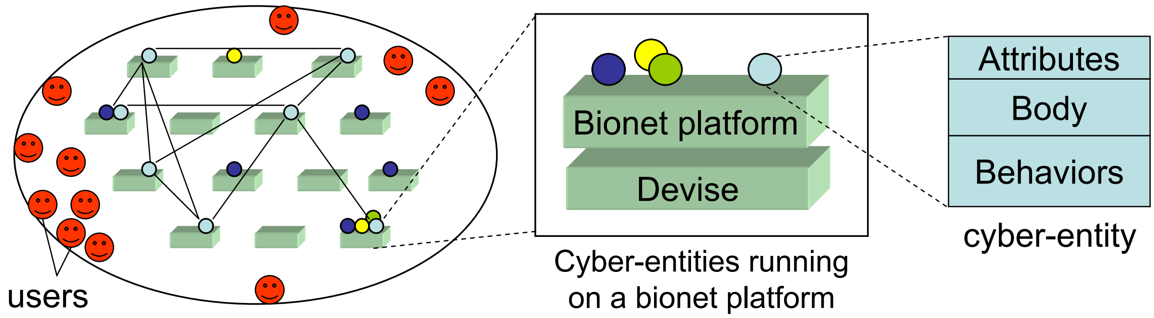
- Emergence
  - Biological systems
    - Useful group behavior (e.g. adaptability and survivability) emerges from autonomous local interaction of individuals with simple behaviors.
      - i.e. not by direction of a centralized (leader) entity
      - e.g. food gathering function
        - » When a bee colony needs more food, a number of bees will go to the flower patches to gather nectar.
        - » When food storage is near its capacity, only a few bees will leave the hive.
  - The Bio-Networking Architecture
    - CEs autonomously
      - sense local/nearby environment
        - » e.g. existence of neighboring CEs, existence/movement of users, workload, availability of resources (e.g. memory space), etc.
      - invoke behaviors according to the condition in a local/nearby environment
      - interacts with each other

- Lifecycle
  - Biological systems
    - Each entity strives to seek and consume food for living.
    - Some entities replicate and/or reproduce children with partners.
  - The Bio-Networking Architecture
    - Each CE stores and expends *energy* for living.
      - gains energy in exchange for providing its service to other CEs
      - expends energy for performing its behaviors, utilizing resources (e.g. CPU and memory), and invoking another CE's service.
    - Each CE replicates itself and reproduce a child with a partner.

- Evolution
  - Biological system
    - adjusts itself for environmental changes through species diversity and natural selection
  - The Bio-Networking Architecture
    - CEs evolve by
      - generating behavioral diversity among them, and
        - » CEs with a variety of behavioral policies are created by human developers manually, or through mutation (during replication and reproduction) and crossover (during reproduction)
      - executing natural selection.
        - » death from energy starvation
        - » tendency to replicate/reproduce from energy abundance

- Social networking
  - Biological systems (social systems)
    - Any two entities can be linked in a short path through relationships among entities.
      - not through any centralized entity (e.g. directory), rather in a decentralized manner.
      - six decrees of separation
  - The Bio-Networking Architecture
    - CEs are linked with each other using *relationships*.
      - A relationship contains some properties about other CEs (e.g. unique ID, name, reference, service type, etc.)
    - Relationships are used for a CE to search other CEs.
      - Search queries originate from a CE, and travel from CE to CE through relationships.
    - The *strength* of relationship is used for prioritizing different relationships in discovery.
      - A CE may change its relationship strength based on the degree of similarity between two CEs.
      - The stronger relationship is likely to lead a query to a successful discovery result.

CE's Structure and Behaviors

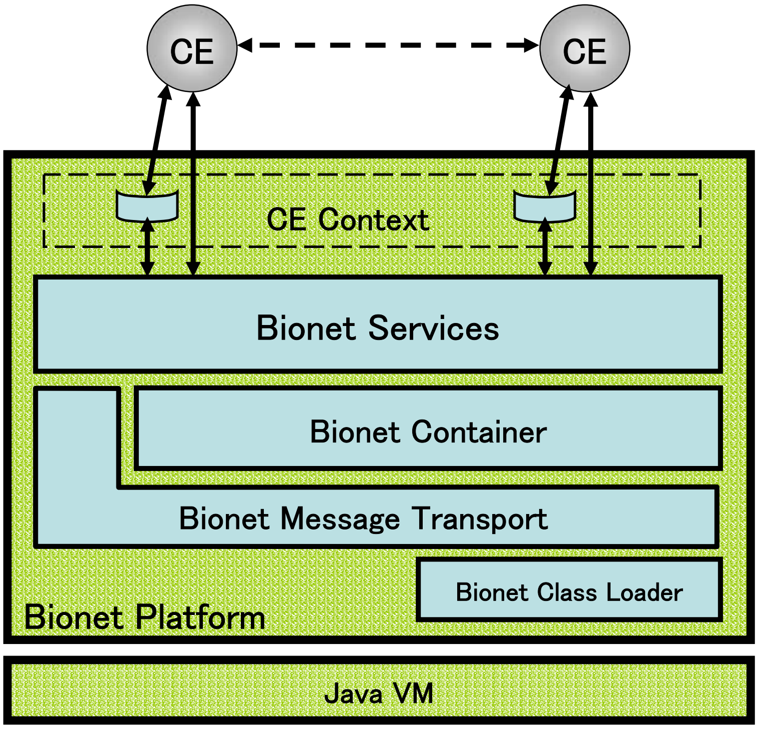


- Attributes
  - ID
  - Relationship list
  - Age
  - ...etc.
- Body
  - Executable code
  - Non-executable data
- Behaviors
  - Energy exchange and storage
  - Communication
  - Migration
  - Replication and reproduction
  - Death
  - Relationship establishment
  - Social networking (discovery)
  - Resource sensing
  - State change

Design Strategies of the Bio-Networking Architecture

- Separate cyber-entity (CE) and Bio-Networking Platform (bionet platform),
  - Cyber-entity (CE)
    - mobile object (agent) that provides any service logic
  - Bionet platform
    - middleware system for deploying and executing cyber-entities
- Model CE and bionet platform with UML
  - Using SDO PIM
- Implement CE and bionet platform in Java and CORBA
  - Using SDO CORBA PSM

Architecture of the Bio-Networking Platform



A *Cyber-entity (CE)* is an autonomous mobile object. CEs communicate with each other using FIPA ACL.

A *CE context* provides references to available bionet services.

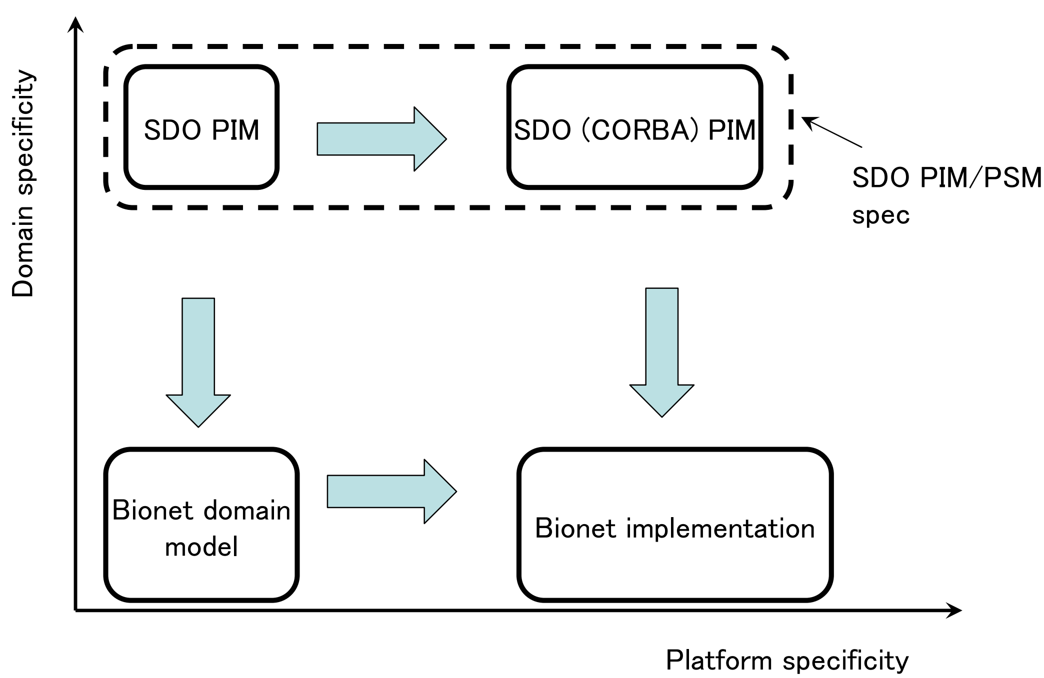
Bionet services are runtime services that CEs use frequently.

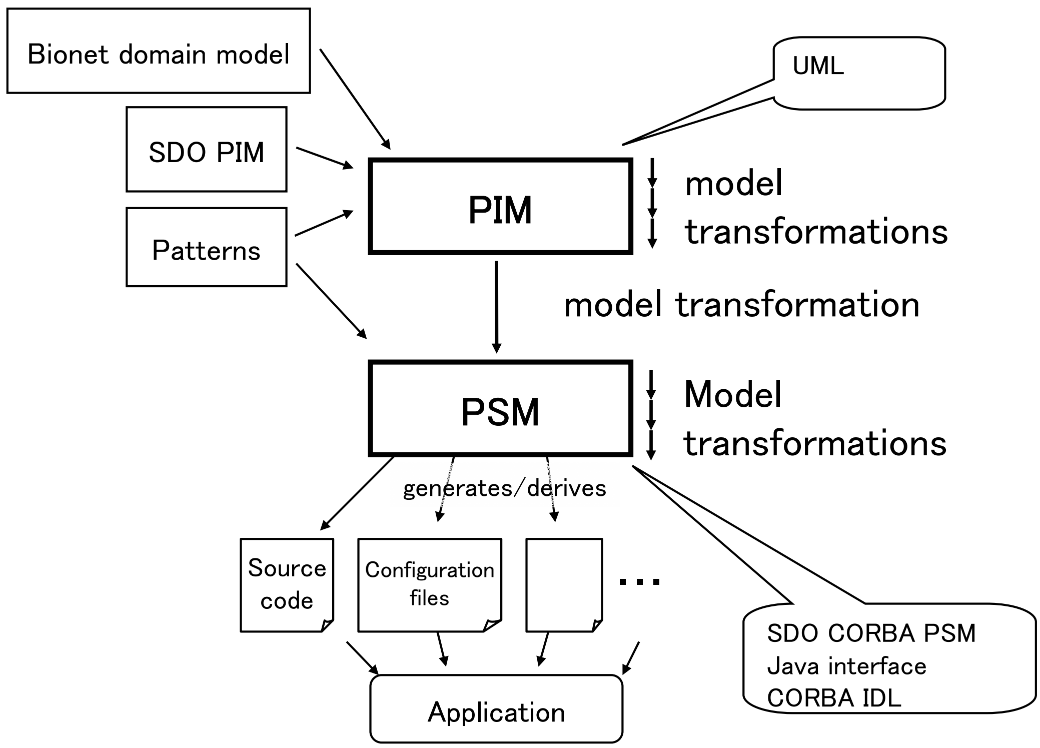
Bionet container dispatches incoming messages to target CEs.

Bionet message transport takes care of I/O, low-level messaging and concurrency.

Bionet class loader loads byte code of CEs to Java VM.

Scope of Bionet Implementation




Bionet domain model
SDO PIM
Patterns
UML
PIM
model
transformations
model transformation
PSM
Model
transformations
generates/derives
Source
code
Configuration
files
…
SDO CORBA PSM
Java interface
CORBA IDL
Application