IBM Research

Siena: a tool for modeling and executing artifact-centric business processes

PhD Seminar -- *Università di Roma "La Sapienza"*
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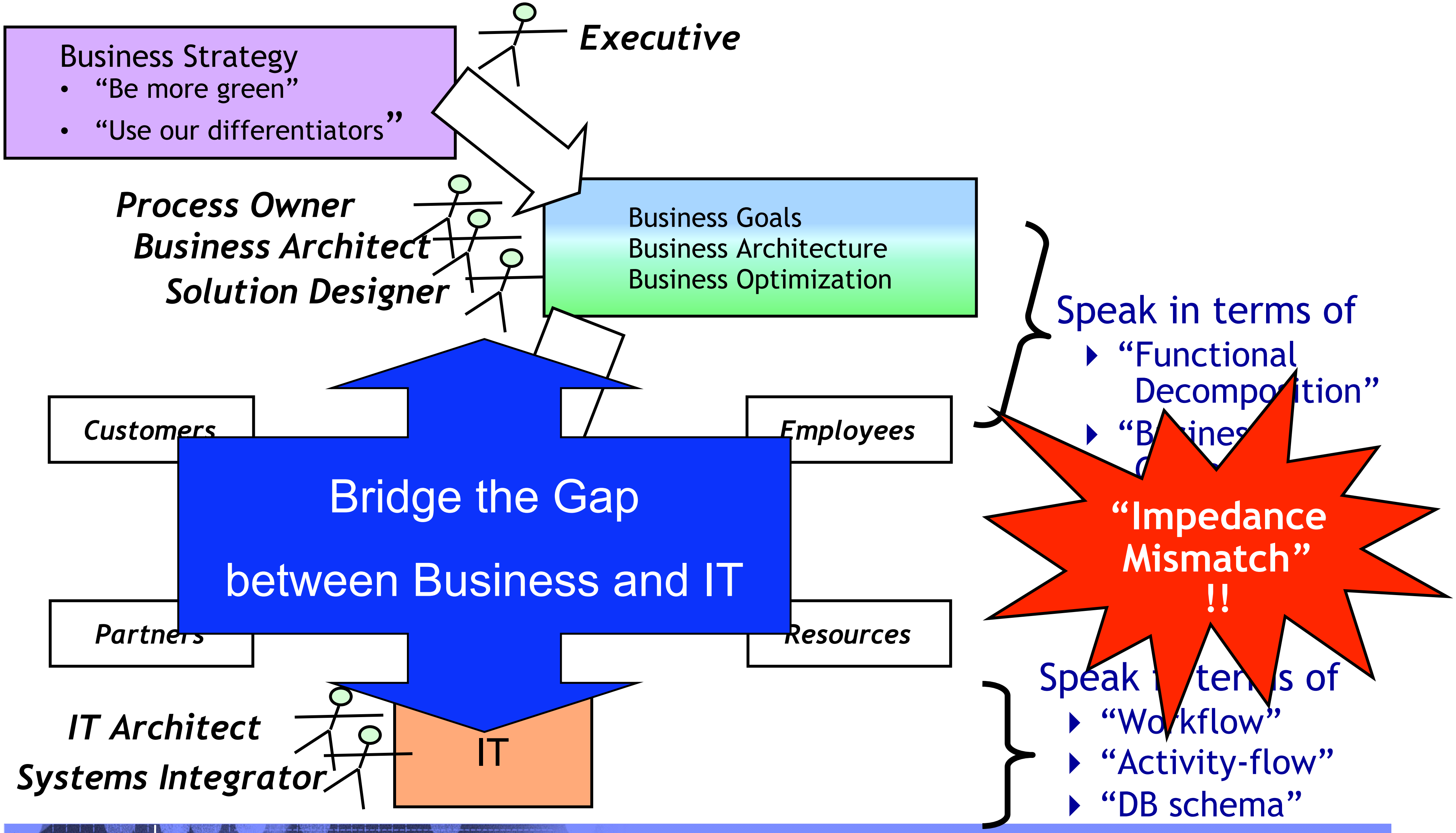
Seminar Agenda

- **Artifact-Centric Approach**
  - Introduction to Business Entities
- **Comparison of Business Process Management Approaches**
  - ***Process-Centric*** approach using Hotel Scenario
  - ***Artifact-Centric*** approach using Hotel Scenario
- **Introduction to Siena**
  - Overview
  - Architecture
- **Siena Demo**
  - Review Hotel example
- **Siena Details**
  - Meta-Model
  - Services
- **Siena Examples**
  - Alessio and Patrizia

A Key Challenge in Business Process Management

(Many Stakeholders in an Enterprise)



Business Strategy

- “Be more green”
- “Use our differentiators”

Executive

Process Owner

Business Architect

Solution Designer

Business Goals
Business Architecture
Business Optimization

Customers

Employees

Bridge the Gap

between Business and IT

Partners

Resources

IT Architect

Systems Integrator

IT

Speak in terms of

- “Functional Decomposition”
- “Business C[illegible]

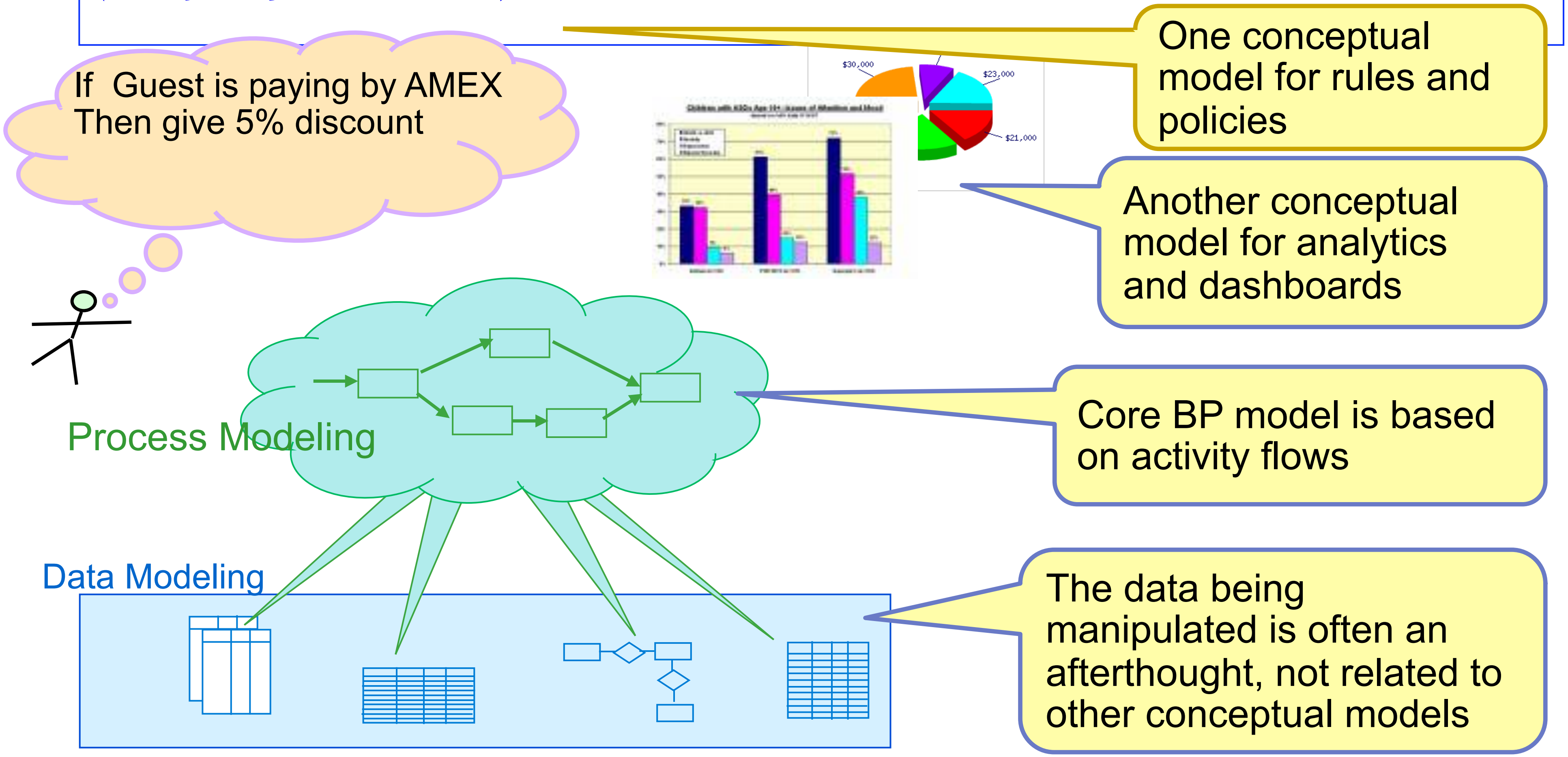
“Impedance Mismatch” !!

Speak in terms of

- “Workflow”
- “Activity-flow”
- “DB schema”

Basic Challenge: Today’s approach to BPM environments is fundamentally disjointed

(Many disjoint Models)



If Guest is paying by AMEX
Then give 5% discount

One conceptual model for rules and policies

Another conceptual model for analytics and dashboards

Process Modeling

Core BP model is based on activity flows

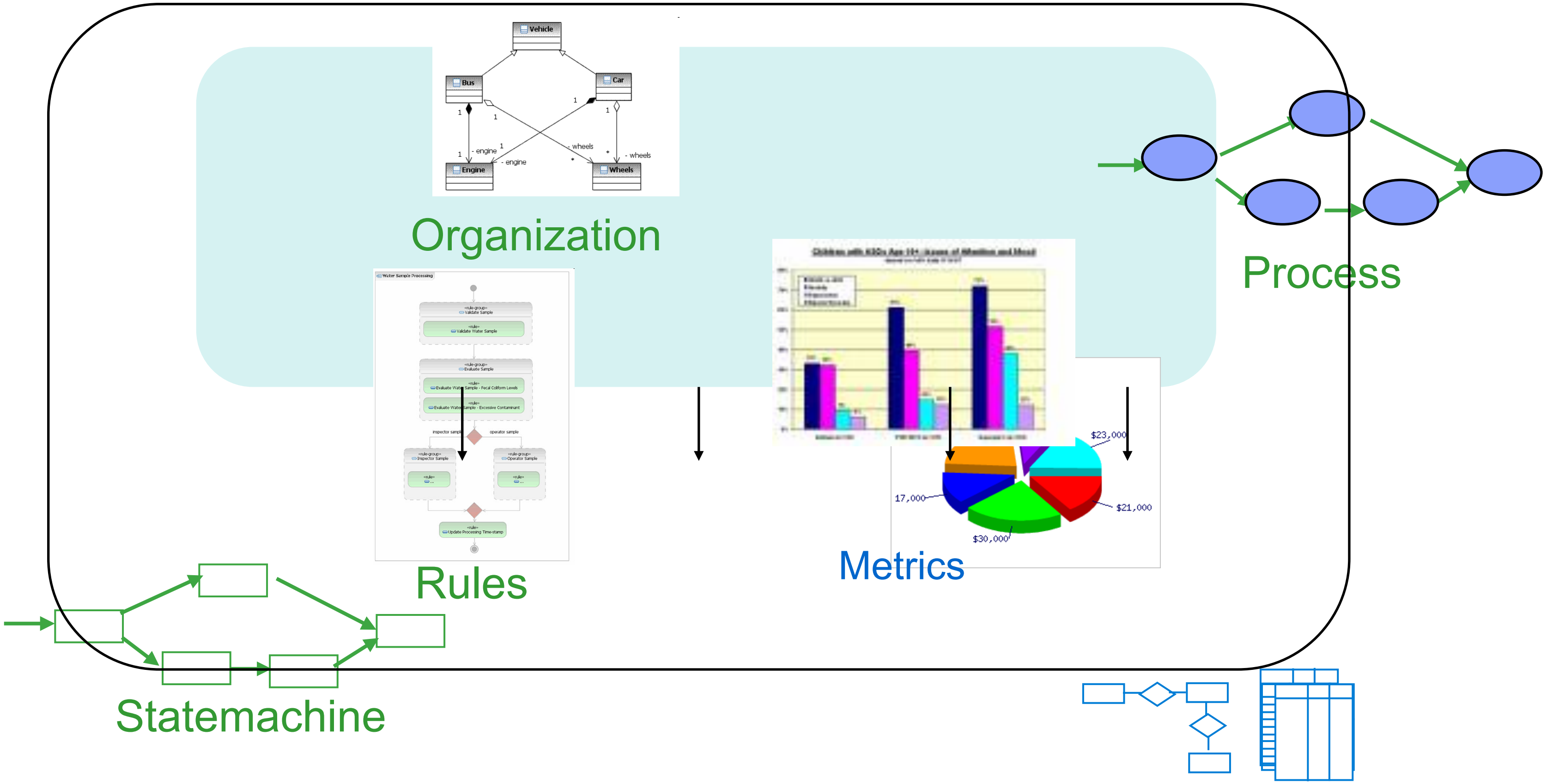
Data Modeling

The data being manipulated is often an afterthought, not related to other conceptual models

Lack of coherence adds substantial complexity
to an already very complex environment

Solution: Unified Business Construct

Business Entity: (e.g. Purchase Order)



Organization

Process

Rules

Metrics

Statemachine

Alignment of Models
Contextualized as a Business Entity
Coherence Achieved

“Business Entities”: data + process combined to form a new, “holistic” foundation for BPM

- **Business Entities are Unifying Business Constructs**
  - Provides a skeleton that cuts across the Business
    - e.g., **Guest Stay**
      - From CheckIn to CheckOut
      - Blending of Data, Rules, Process, Measurements in the context of a Guest Stay

- **Includes specification of both**
  - The ***information model***, to hold relevant data about an artifact as it moves through the workflow, and
  - The ***possible lifecycles*** it might follow

- ***Insight:*** Gives business managers a unified, end-to-end view of their business operations
- ***Communication:*** Numerous stakeholders have a common basis for understanding
- ***Actionable:*** Natural mapping to organization & IT levels

Brief comparison of BPM approaches

Process-Centric Approach

- **Business Data is**
  - **NOT** the primary focus
  - Business data is merely an after thought
- **Process Steps are the main concern**
  - *What* do humans ***do*** in the business
  - *What* systems ***need*** to be integrated

Artifact-Centric Approach

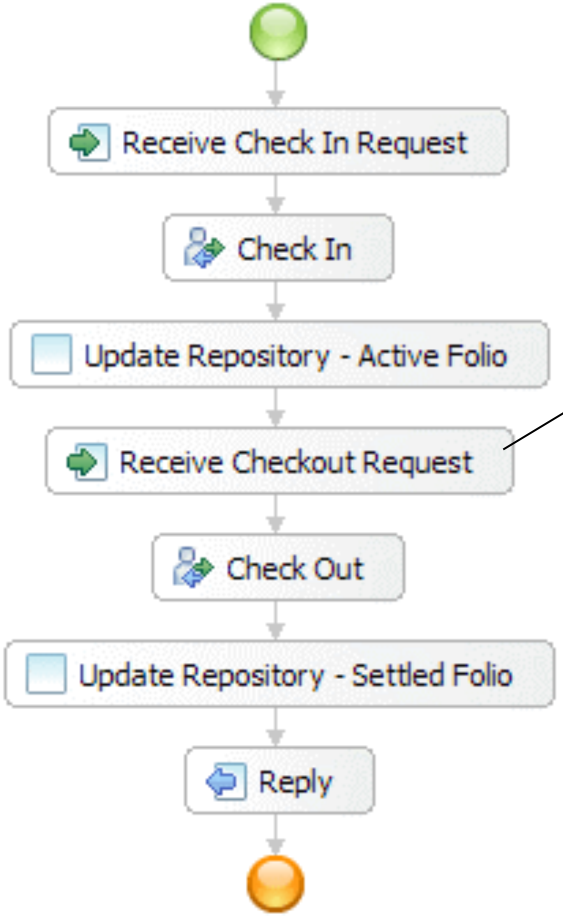
- **Business Data is**
  - The **PRIMARY** focus
- **Process steps occur in context**
  - The ***"Business Entity"*** needs *which* humans to do something to it.
  - The ***"Business Entity"*** needs to integrate with *what* certain systems.

Review of Hotel Scenario for comparison

- **Posting charges to the guest folio during a hotel stay**
- **Base scenario**
  - –Guest checks in
  - –Room charges are posted by the Night Audit process
  - –Guest dines in the hotel restaurant
  - –Guest checks out
- **Scenario evolution 1 – Handling of “lost” charges**
  - –Guest has breakfast after checking out
- **Scenario evolution 2 – Handling of charges by “drop-ins”**
  - –A non-guest dines at the hotel restaurant

Process-Centric approach for Hotel scenario

Check in- Checkout Process
(Process-Centric Approach)

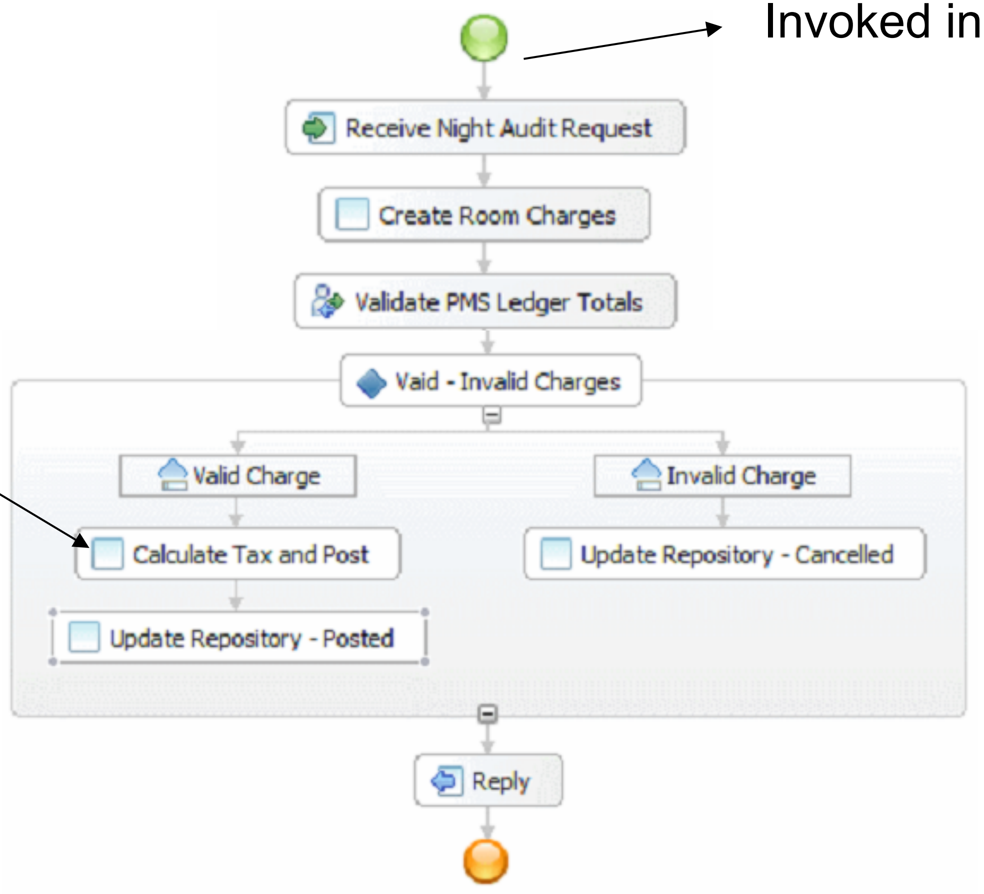


Waiting for Checkout Request

Long Running Flow:

- Remains active until Guest checks out
- The Guest Stay information is hidden in the long running process instance data

Night Audit Process – Modeled as separate process
(Process-Centric Approach)


Receive Night Audit Request
Create Room Charges
Validate PMS Ledger Totals
Vaid - Invalid Charges
Valid Charge
Invalid Charge
Calculate Tax and Post
Update Repository - Cancelled
Update Repository - Posted
Reply

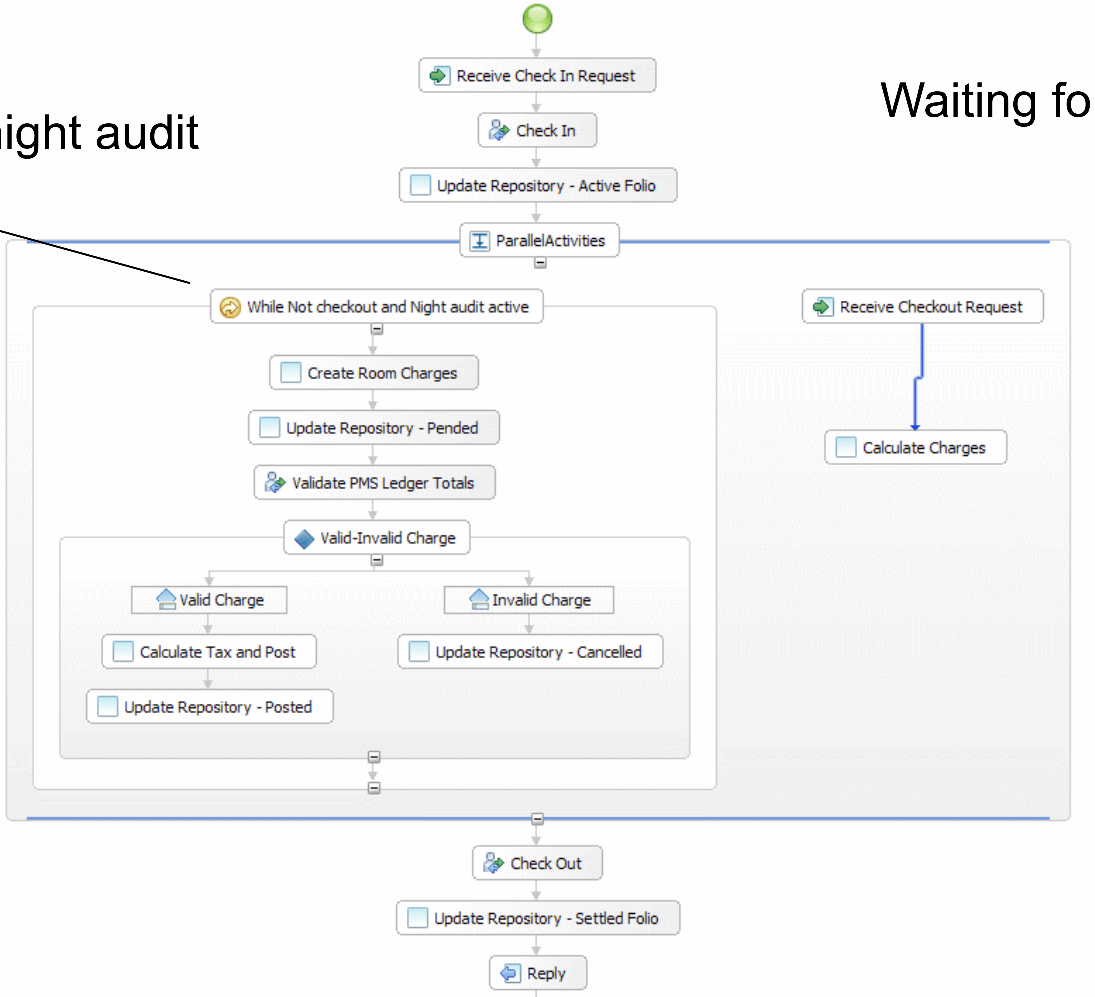
Invoked in Batch via Scheduler

Posting to Folio

- Multiple instances of the process created for each day for each guest
- No direct link between check in process and night audit process.

Combined check in- Checkout and Night Audit Process

(Process-Centric Approach)

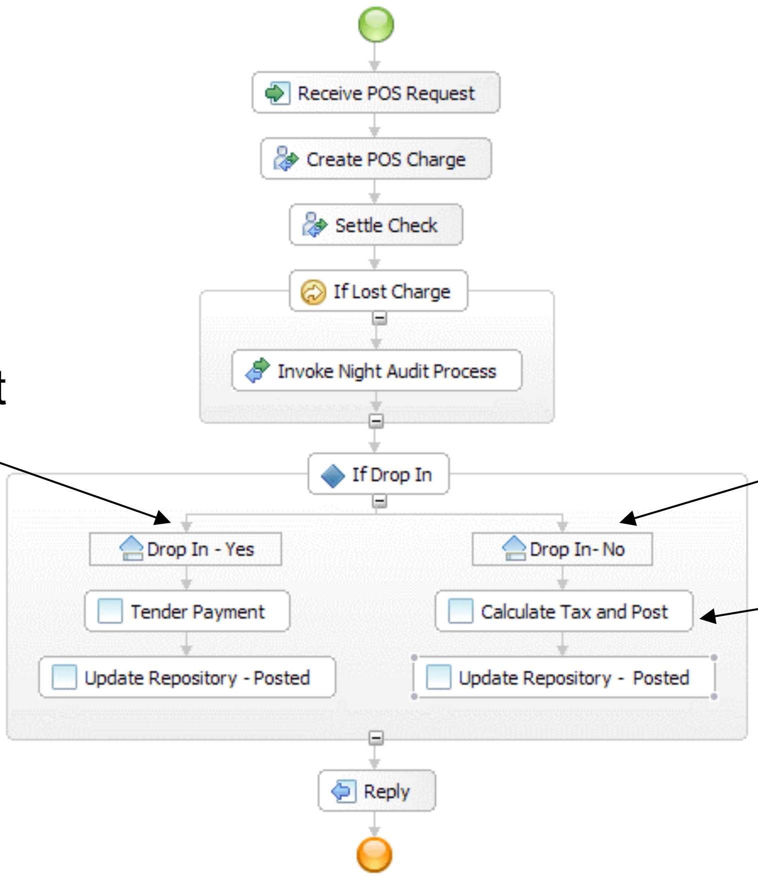

Receive Check In Request
Check In
Update Repository - Active Folio
ParallelActivities
While Not checkout and Night audit active
Create Room Charges
Update Repository - Pended
Validate PMS Ledger Totals
Valid-Invalid Charge
Valid Charge
Invalid Charge
Calculate Tax and Post
Update Repository - Cancelled
Update Repository - Posted
Receive Checkout Request
Calculate Charges
Check Out
Update Repository - Settled Folio
Reply

Infinite loop for night audit

Waiting for Checkout Request

Night audit process modeled as part of main flow to avoid multiple process instances being created.

Point of Sale (POS) Process
(Process-Centric Approach)



Non-hotel Guest

Hotel Guest

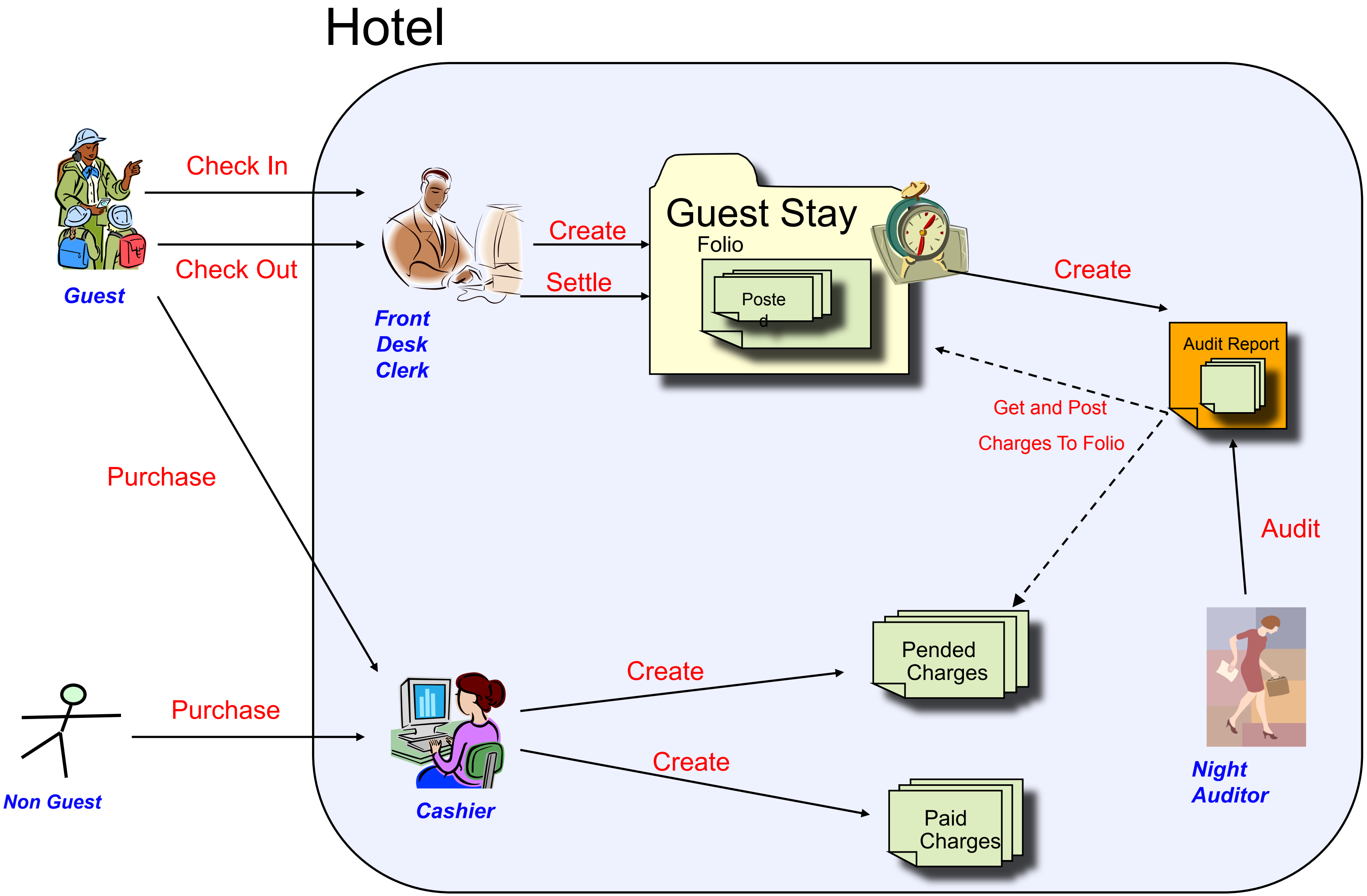
Posting to Folio

POS modeled as separate process as this can be instantiated independently any number of times.

Summary
(Process-Centric Approach)

- **Discrete/Disjoint Processes**
- **Data is an after thought**
- **Guest stay information lost in long running process instances**
- **Lots of additional coding needed to integrate to Databases and Services**

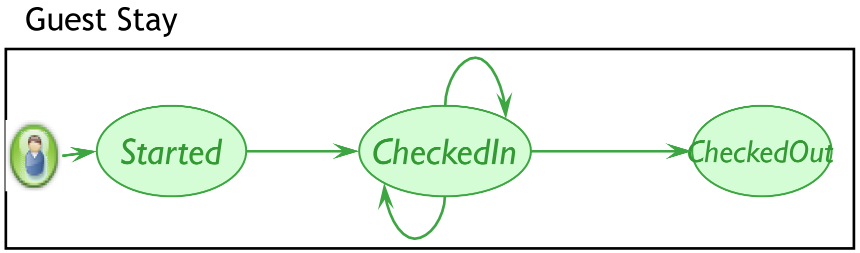
Artifact-Centric Hotel Scenario



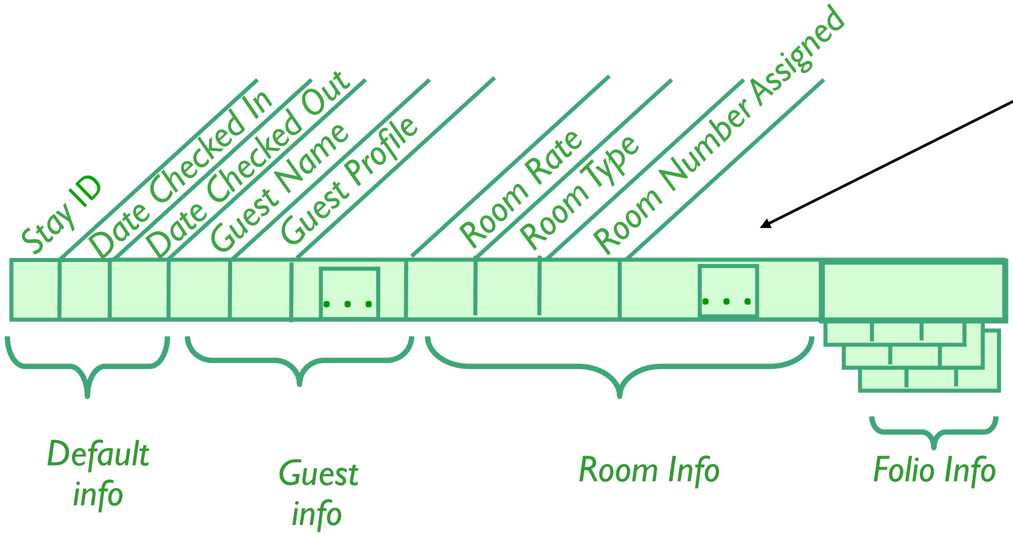
Entity-Centric approach of Hotel Scenario

- **Identify key Business Entities**
  - –Guest Stay
    - States: Started, CheckedIn, RoomAssigned, CheckedOut
    - Information: Stay_ID, CheckInDate, CheckOutDate Guest Name, Guest Profile, Guest Type,, Room Rate, Room Preferences, Room Number Assigned, Folio Info
  - –Guest Folio
    - States: Started, Active, Settled
    - Information: Folio_ID, Guest Name, Room Number Assigned
  - –Charge
    - States: Start, Pended, Paid, Posted, Lost, Cancelled
    - Information: Charge_ID, Date Incurred, Charge Type, Room Number, Payment Type, ItemInfo(code,desc, qty, cost), TaxInfo(Tax Rate, Desc, TaxTotal)
  - –Night Audit
    - States: Started, InProgress, Completed
    - Information: Audit_ID, Stay_ID, Folio_ID, GuestName, Room Number, DataAuditStarted, DateAuditCompleted. reconciledCharges(1..n)

Guest Stay Entity
(Artifact-Centric approach)



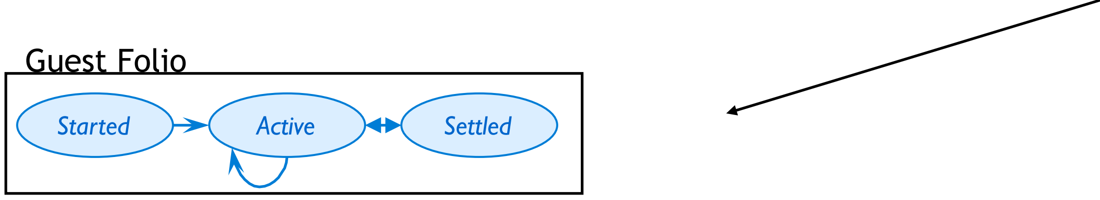
Lifecycle



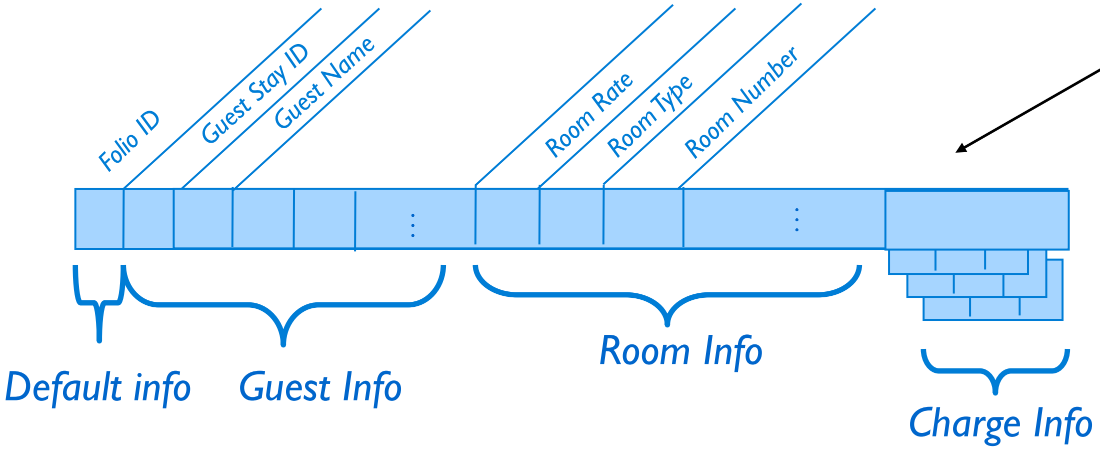
Information Model

Folio Entity
(Artifact-Centric approach)

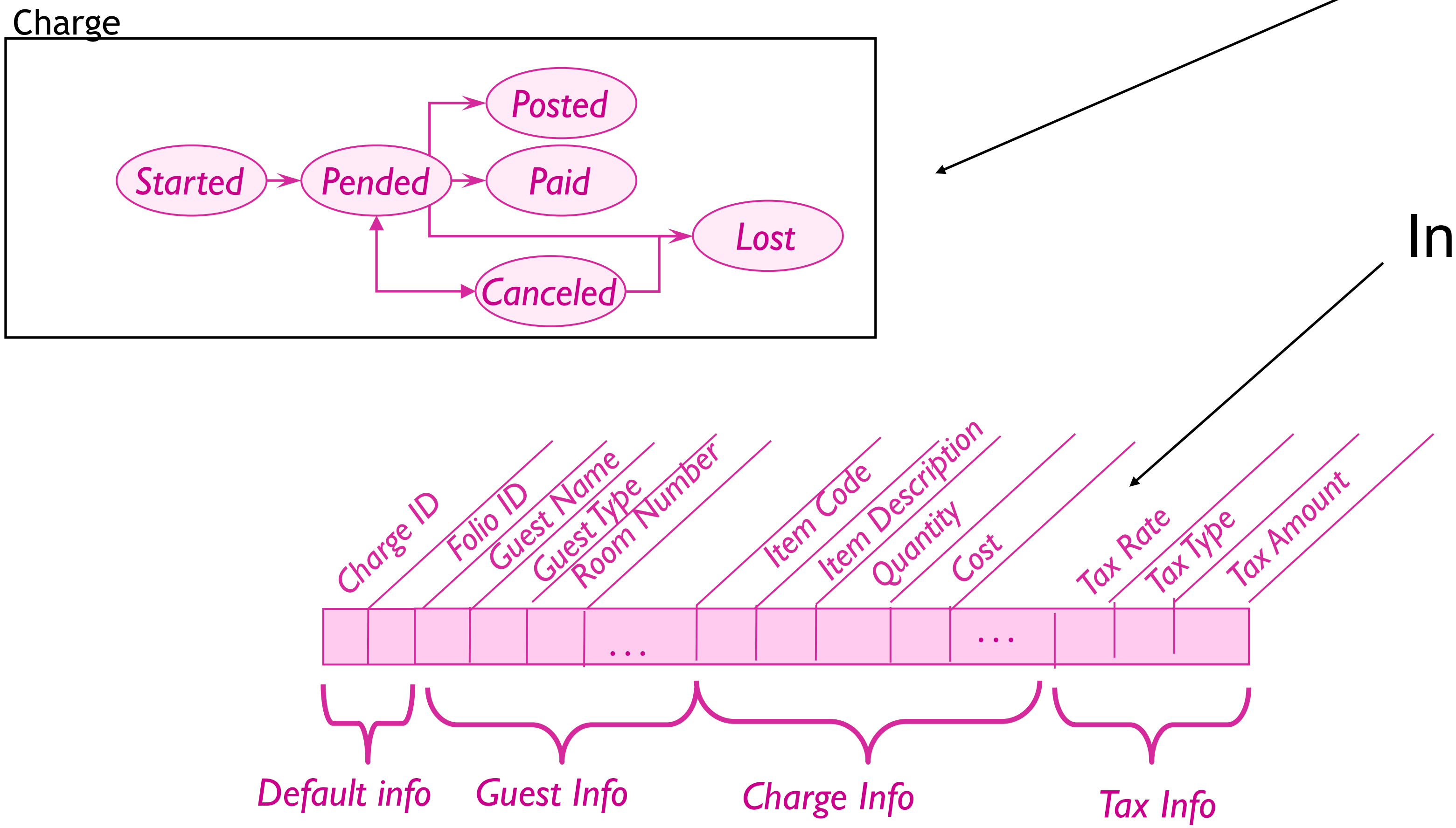
Lifecycle



Information Model



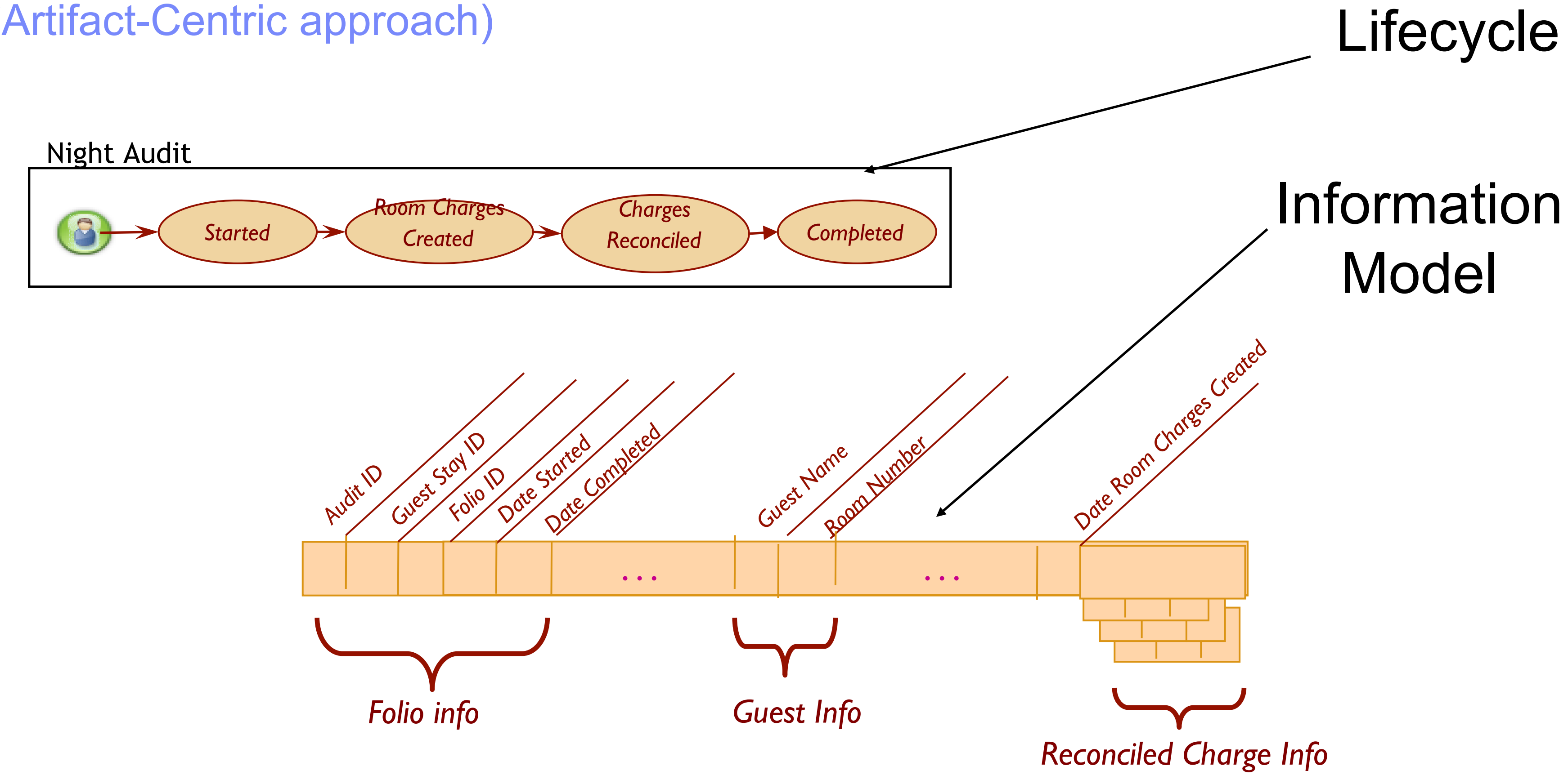
Charge Entity
(Artifact-Centric approach)



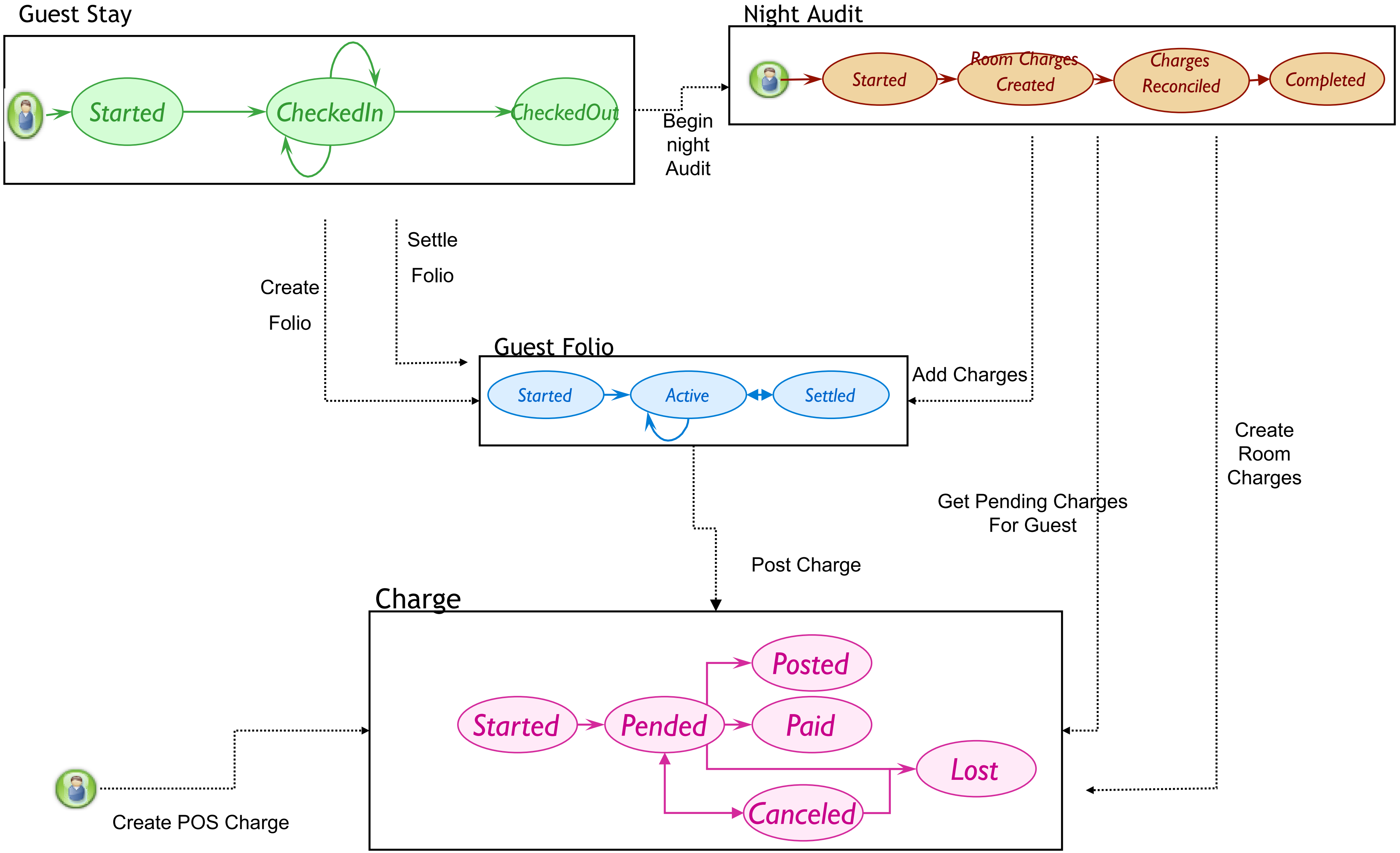
Lifecycle

Information Model

Night Audit Entity
(Artifact-Centric approach)



Business Entity Lifecycles and Business Entity Interactions



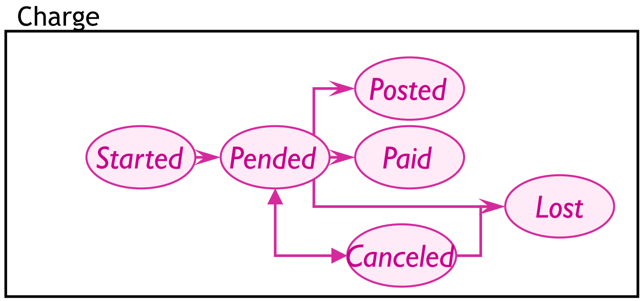
Some comparison points

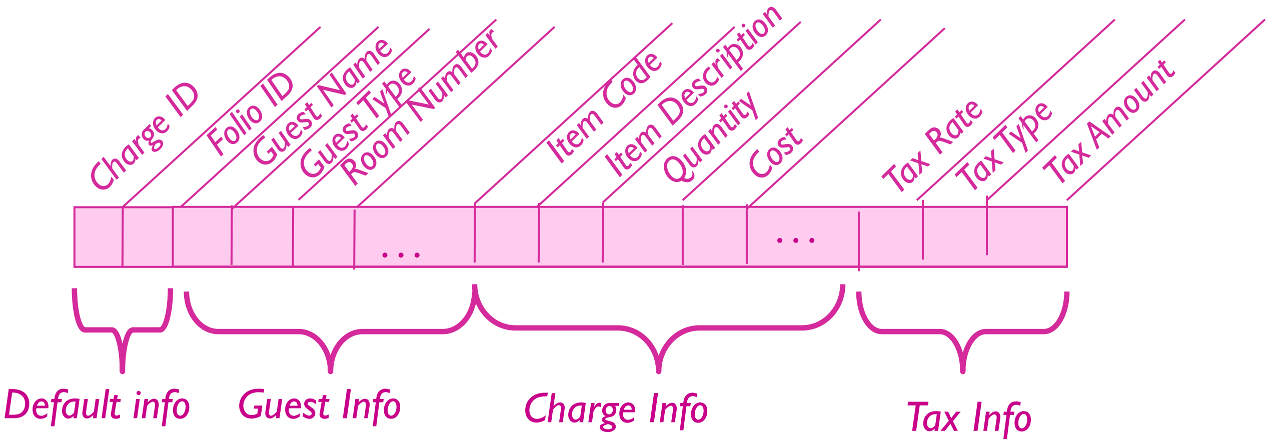
- **Process-Centric Approach**
  - Process flows act as controllers
  - Data is an after thought
  - Some Operational data hidden in long running process data
  - Humans work on “blocked” tasks in long running flows
  - Performance of long running flows not desirable

- **Artifact-Centric Approach**
  - Entities act as controllers
  - Data is Core
    - Business Entities accessible in DB
  - All Operational data stored in Business Entities
    - Queryable, Trackable, Measurable
  - Humans work on Business Entities that are ready for their contribution
  - Performance of Entities (info, lifecycle, micro flows) considered acceptable

Business-Entities provide improved communication among stakeholders in the business

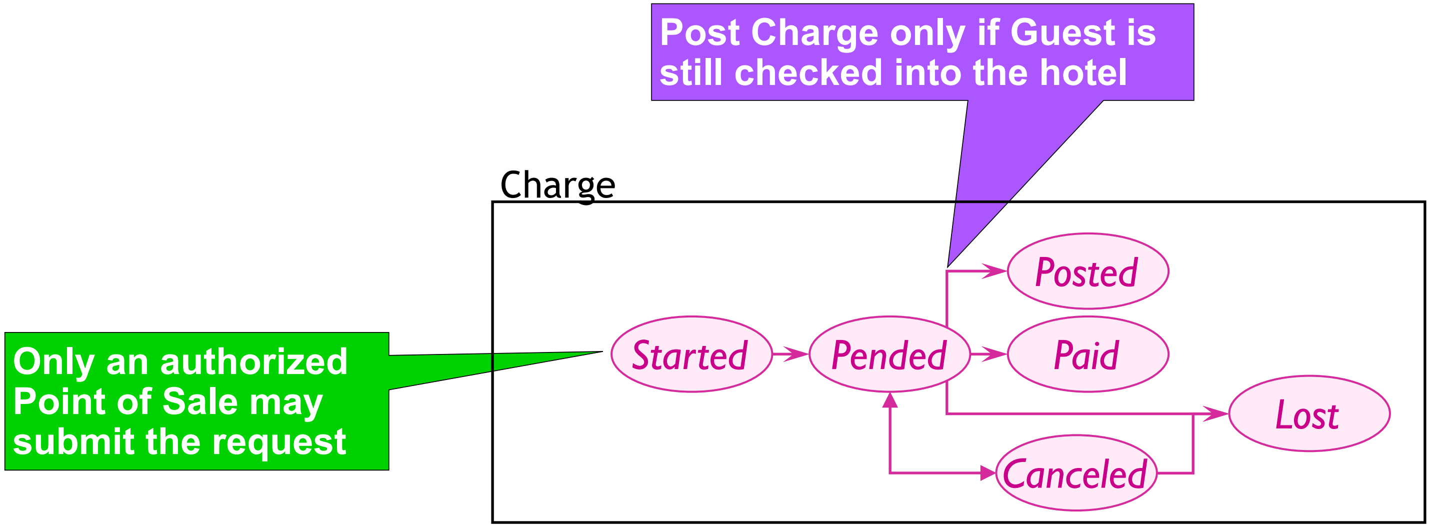
- **“Along” the artifact:**
  - People at “PENDED” can discuss meaningfully with people at “POSTED”
  - Can discuss attribute values produced, needed by different tasks
- **“Across variations”:**
  - Different regions can communicate using shared abstract model
    - ***(Variation of Rules in lifecycles and Process Steps)***
- **“Up/down management chain”**
  - Artifact approach lends itself to more abstract / more detailed specifications





Business Rules Constrain Access, Lifecycle, and Behavior

Business rules define task details & variations


Post Charge only if Guest is still checked into the hotel
Charge
Only an authorized Point of Sale may submit the request
Started
Pended
Posted
Paid
Lost
Canceled

- Rules define how lifecycles can be traversed

- Rules can also define how flows, and data can be manipulated

Introduction to Siena

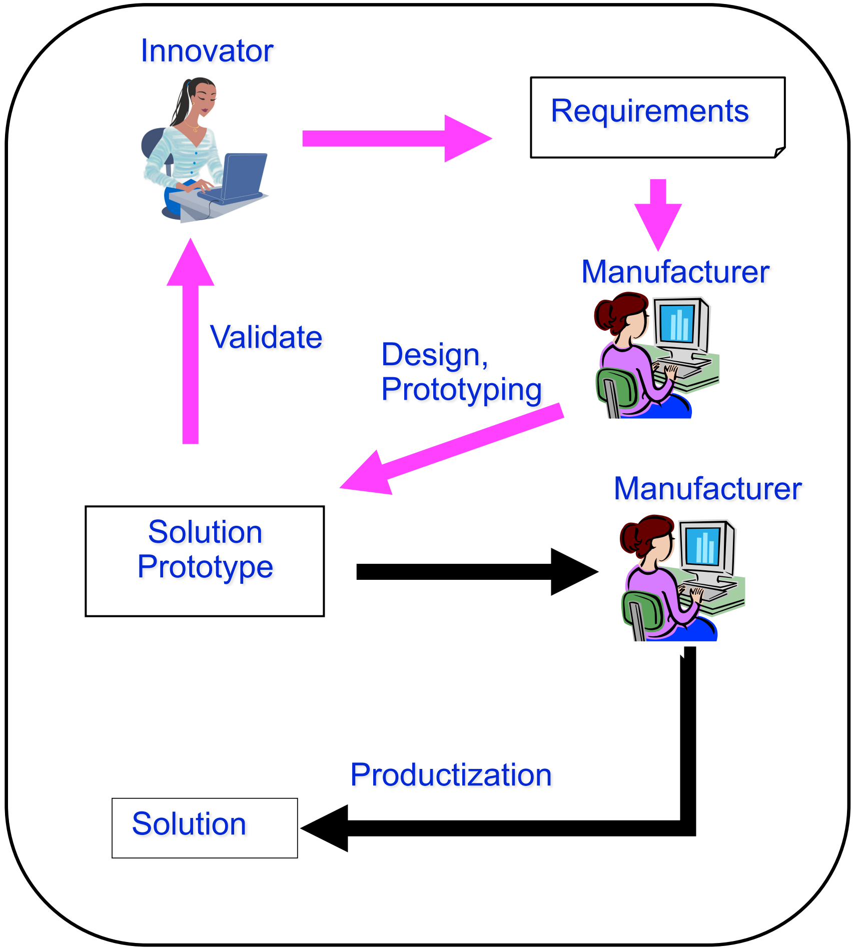
(Light-weight Artifact-Centric Modeling and Execution tool)

- **Empower SME's to easily Innovate new processes**
  - Tools and Runtime often too heavy and hard to understand
  - Innovators currently dependent on IT teams

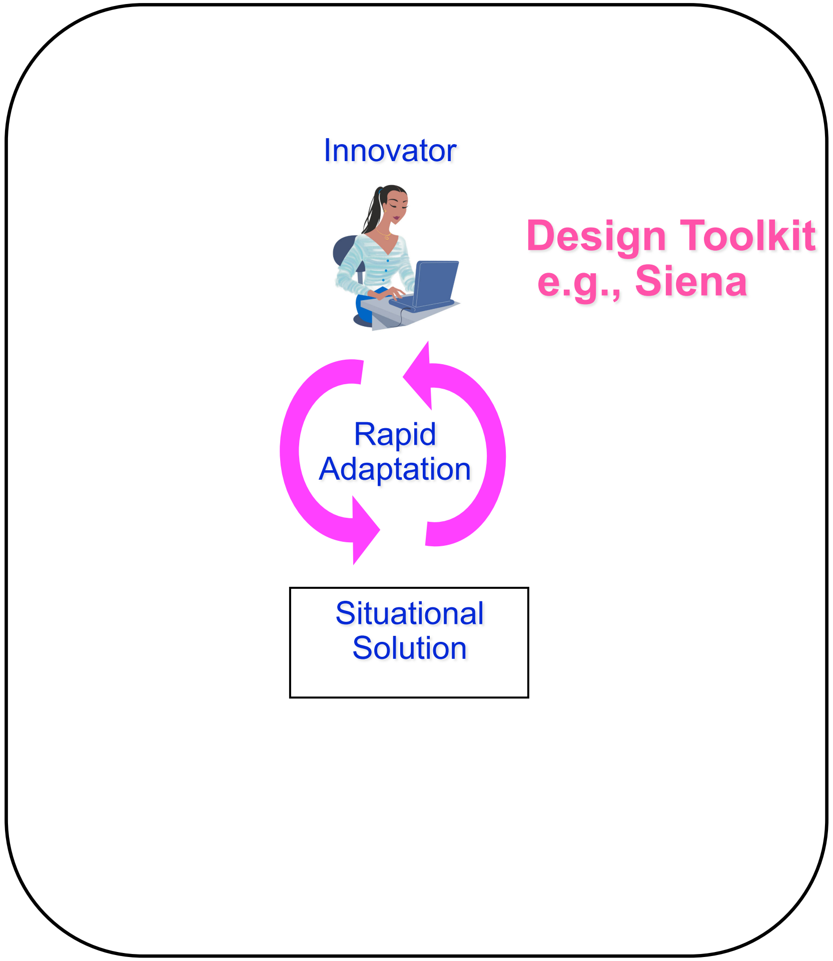
- **Radical Simplification of Tools and Runtime**
  - ***Siena Core Meta Model***
    - Describes semantics for all modeling constructs of Business Entities
  - ***Model Management Engine***
    - ***Web UI Modeling*** tool for producing Business Entity models
  - ***Model Execution Engine***
    - Default Execution UI for deploying and executing Business-Entity models
    - Directly executes Business Entity models
    - No coding necessary, No code generation
    - Small footprint can be easily hosted anywhere including laptop

Innovator’s toolkit for Business Process Modeling

(Democratization of Innovation -- Eric Von Hippel)



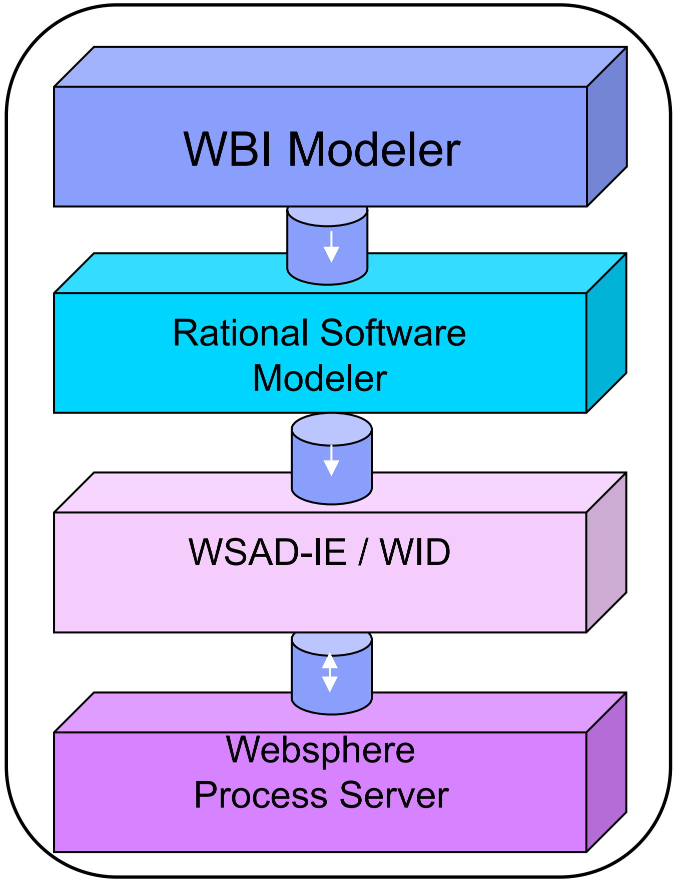
Manufacturer-centered innovation



Innovator-centered innovation

Radical Simplification of Tools and Runtime

(Supporting Business Process Management Applications using Entity Centric Modeling)



WBI Modeler

Rational Software Modeler

WSAD-IE / WID

Websphere Process Server

Tooling Stack

10 Gigs Download/Disk Space, 1-2 Days successful installation, At least 2 Gigs Memory

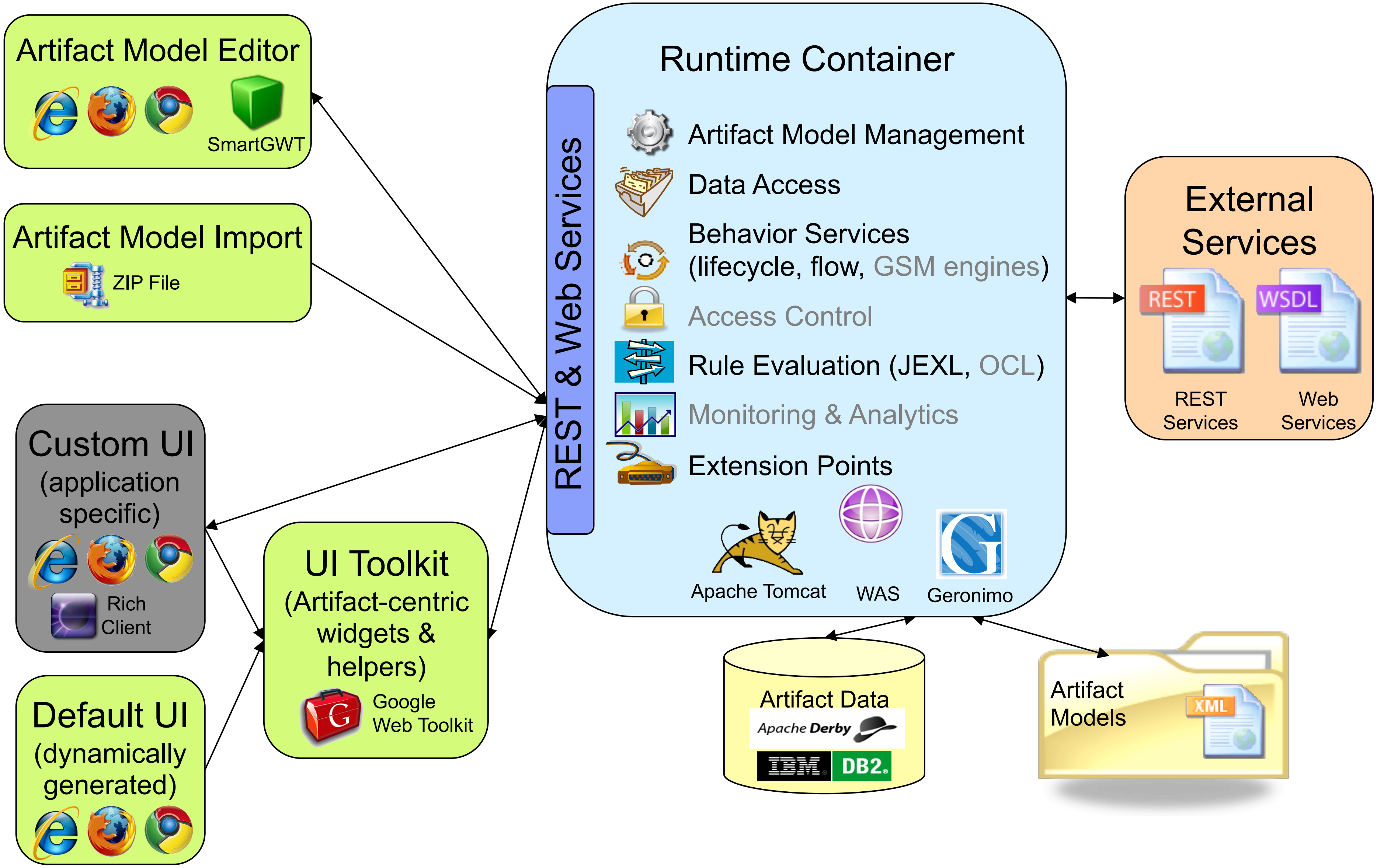
Dreaming of being lighter and more Agile

Firefox®
The award-winning
Web browser

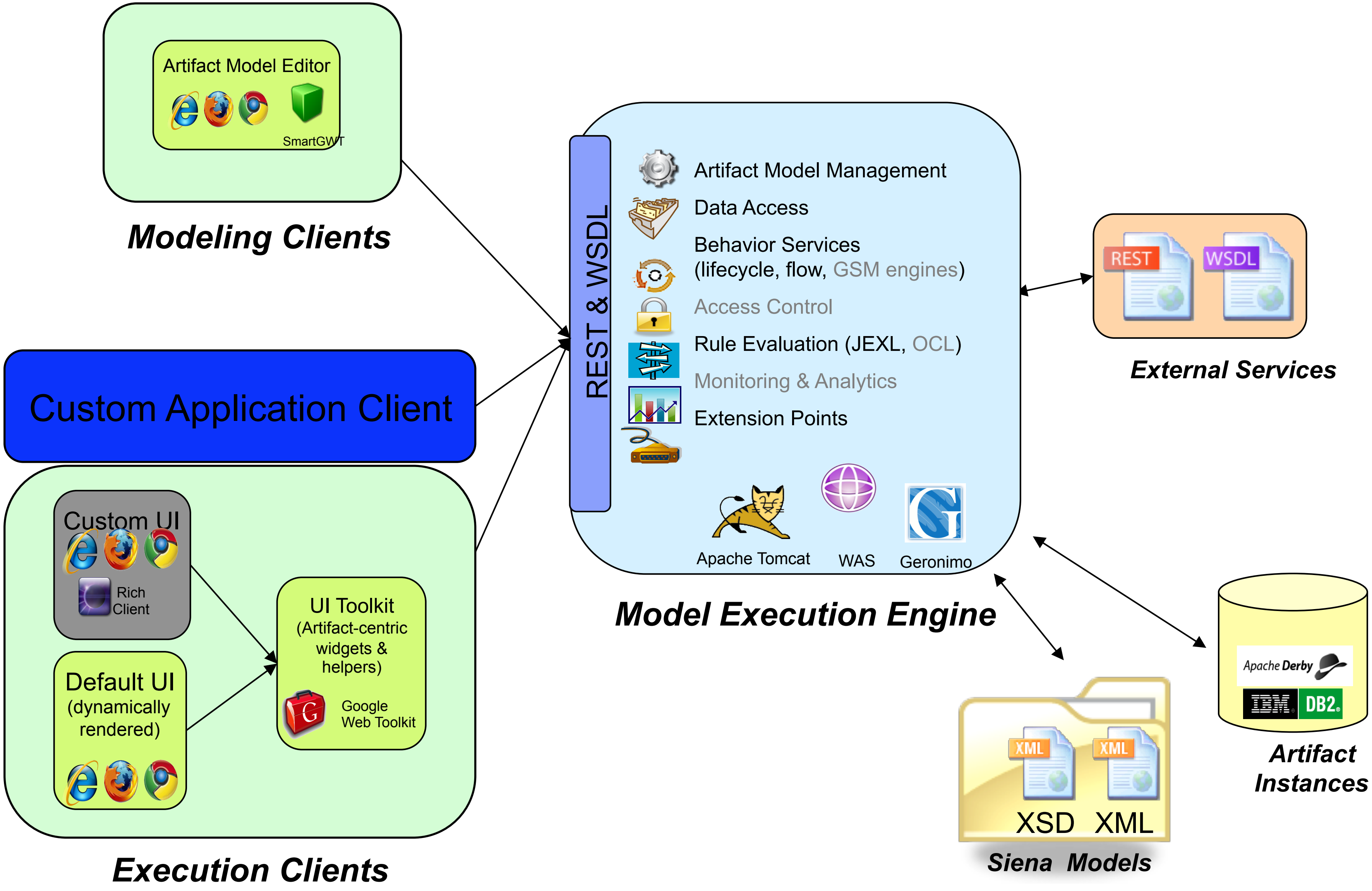
50 Megs Download/Disk Space, 5-10 minutes, < 1 Gig Memory

Reduced set of BPM abstractions to define and create BPM solutions.

Siena Architecture Diagram

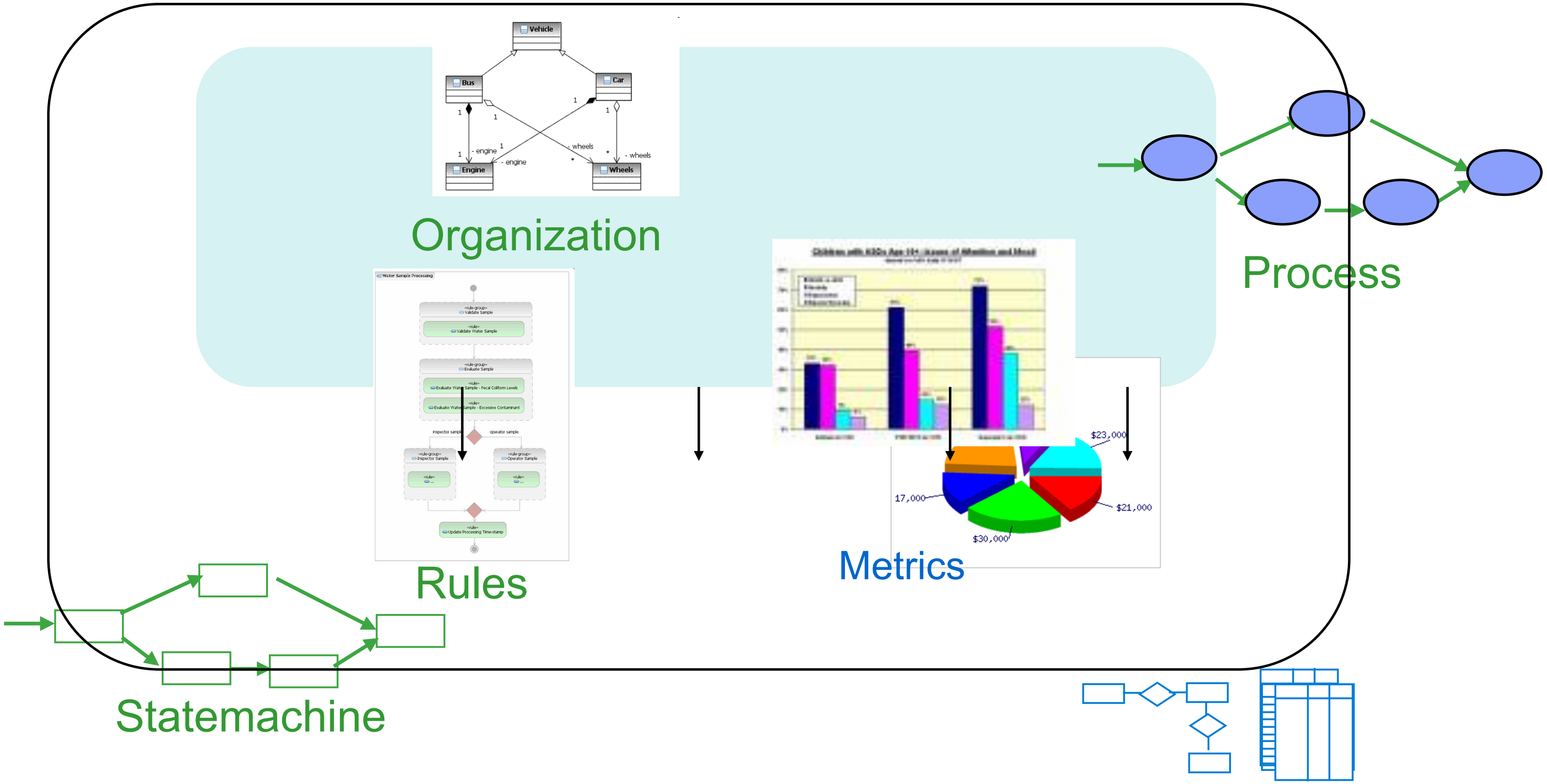


Siena Architecture Diagram



What is a Business Entity: a Unified Business Construct

Business Entity: (e.g. Purchase Order)



Organization

Process

Rules

Metrics

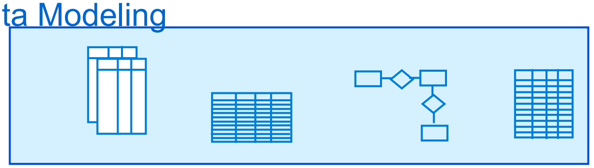
Statemachine

Alignment of Models
Contextualized as a Business Entity
Coherence Achieved

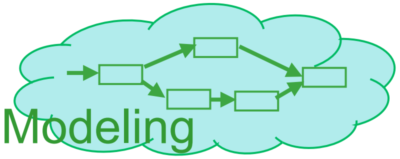
Review: What is a Business Entity? (Deeper Inspection)

- **It's a Unifying Business Construct:**
  - ***Structured by***
    - Core business data models
    - Artifact lifecycles
      - State machines (Siena)
      - Declarative stages (Project ArtiFact™)

Data Modeling



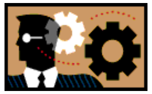
  - ***Providing Services***
    - Transition services
    - Data services
    - Flow services



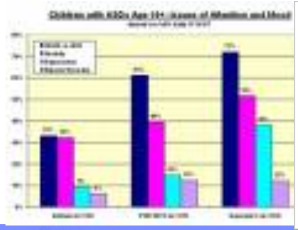
Process Modeling

  - ***Protected by Access Control***
    - Users and Roles
    - Entitlements
      - Data access rights
      - Service access rights

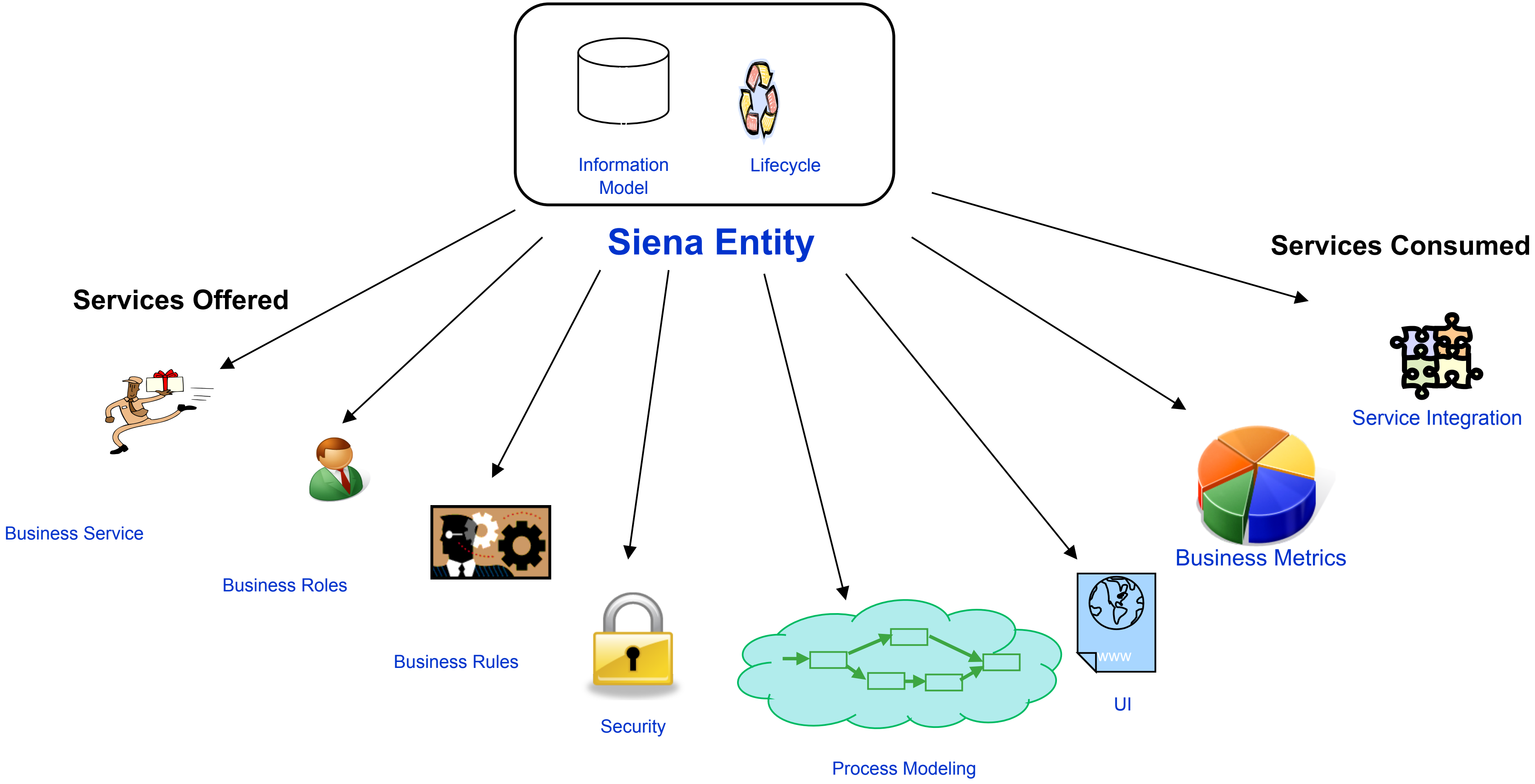
  - ***Constrained By Business Rules***:
    - Data, services, lifecycles, flows, behavior



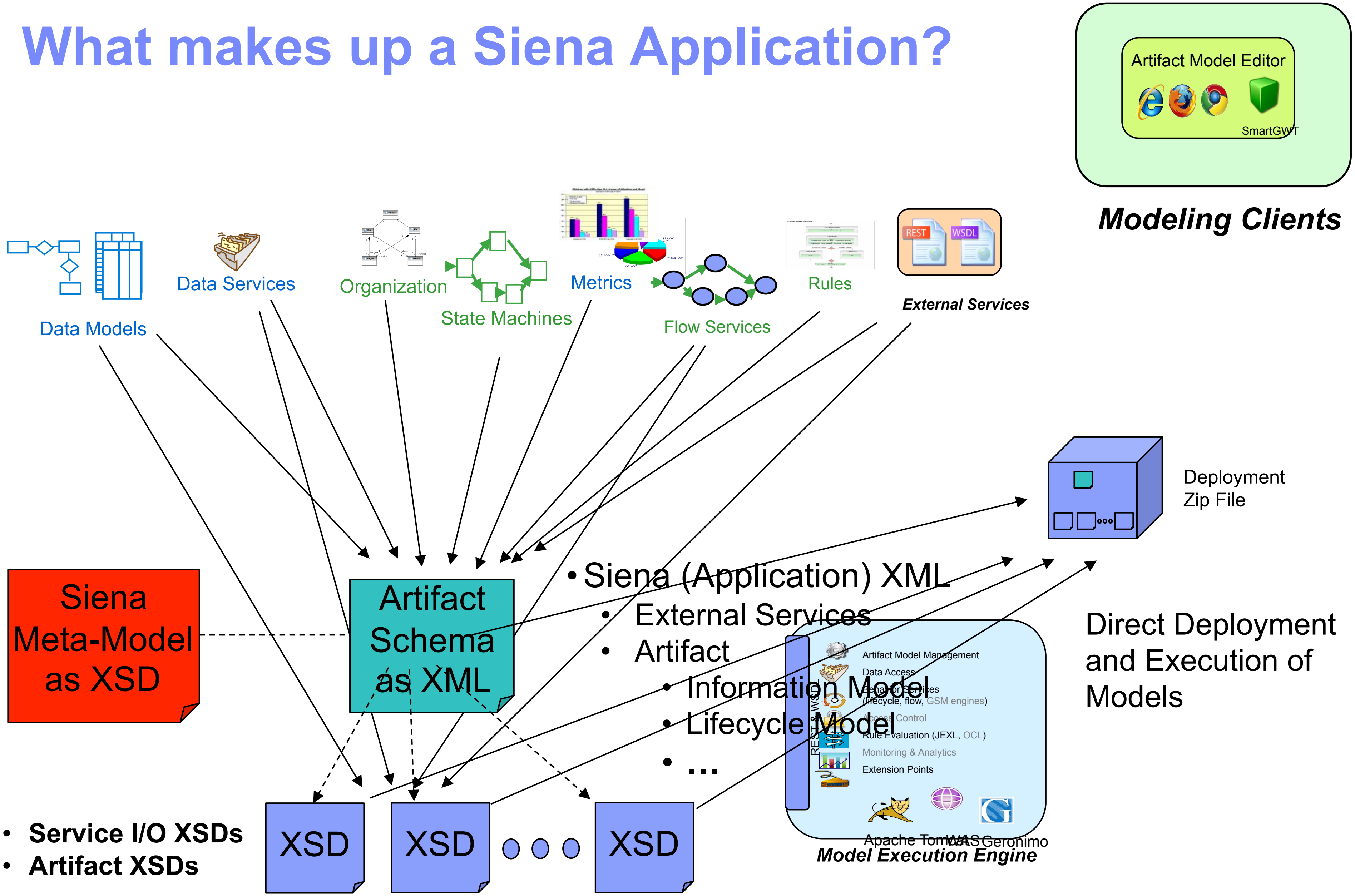
  - ***Has measurable features***
    - Data, lifecycles, flows, tasks



Siena Entity *(The Core of Siena)*



What makes up a Siena Application?



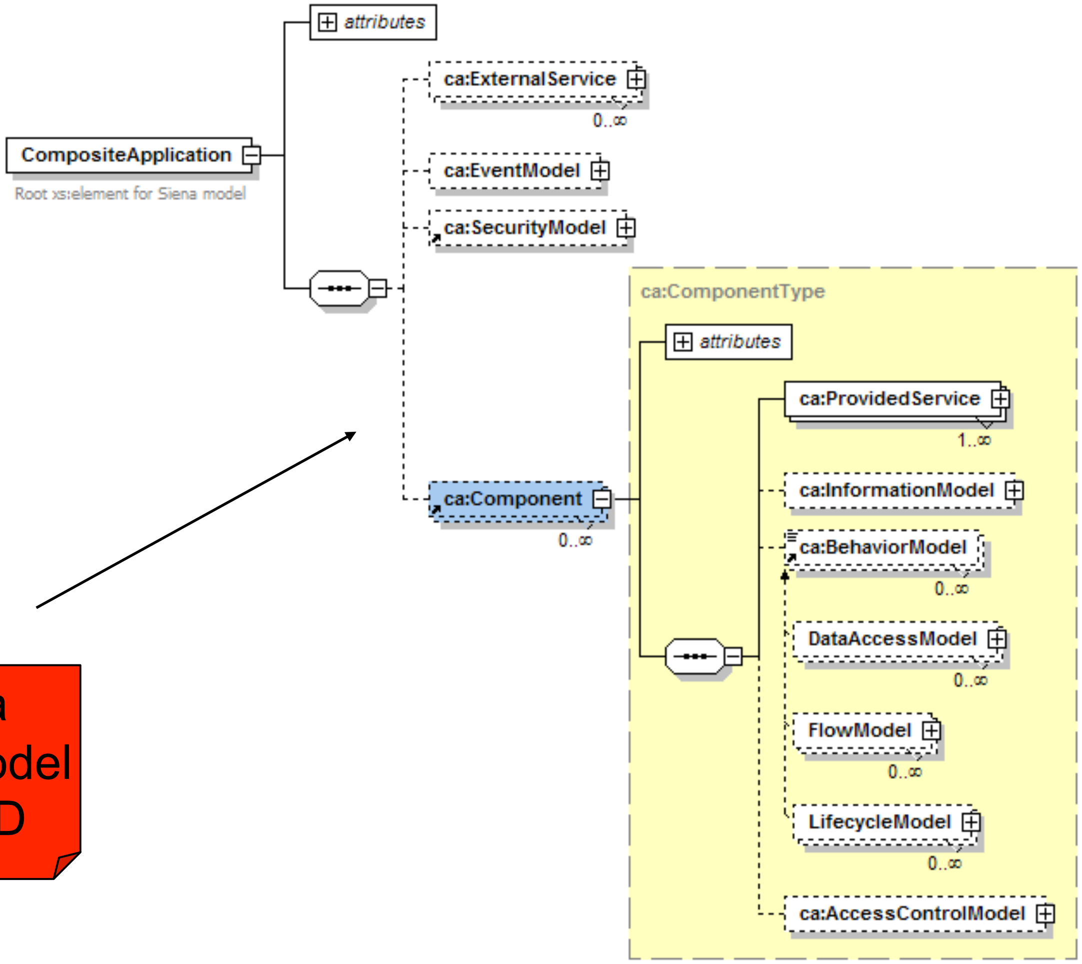
- Siena (Application) XML
  - External Services
  - Artifact
    - Information Model
    - Lifecycle Model
    - …

Direct Deployment and Execution of Models

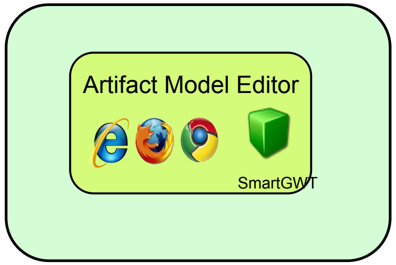
- **Service I/O XSDs**
- **Artifact XSDs**

Siena Schema (Meta-Model)

Composite Application

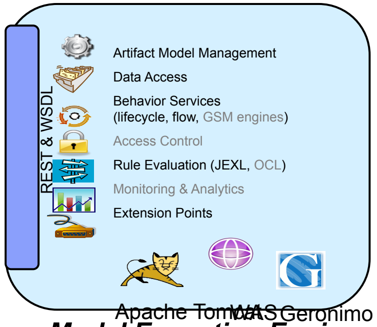


Siena Meta-Model as XSD



Modeling Clients

- ***Produce Model Instances***
- ***Constrained by Meta-Model***



Model Execution Engine

- ***Uses Meta-Model to Execute Model Instances***

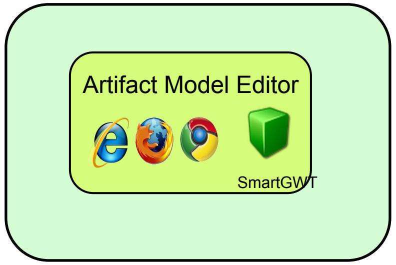
Generate Java from Siena Meta-Model

Siena Meta-Model as XSD

Generate

XSD 2 Java

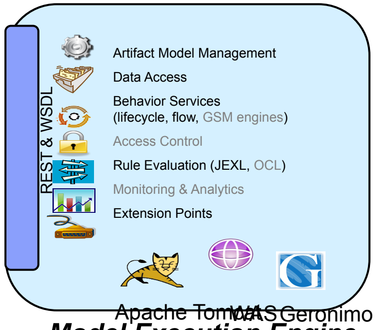
Java Classes



Modeling Clients

- Java Classes used to create Siena Model Instances

- Java Classes used to execute Siena Model Instances



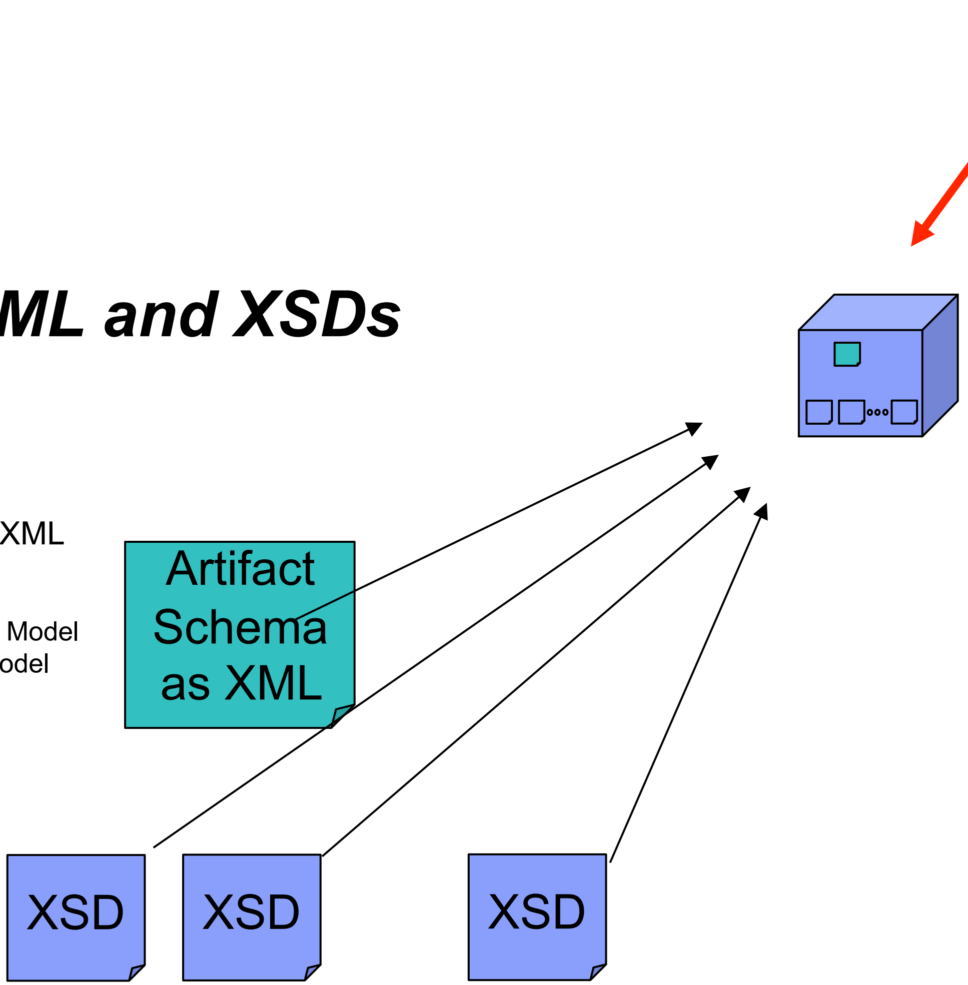
Model Execution Engine

Model Driven Architecture

The Siena Model

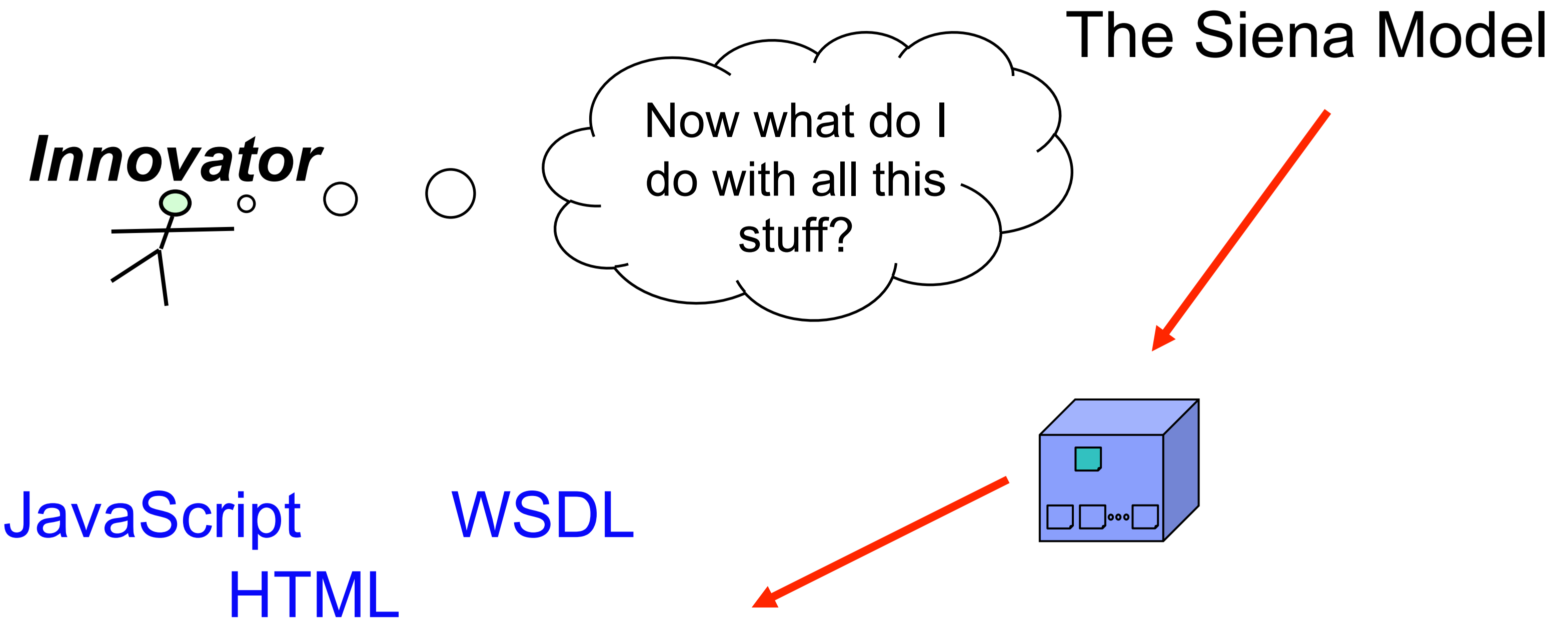
Model is XML and XSDs

- Siena (Application) XML
    - External Services
    - Artifact
        - Information Model
        - Lifecycle Model
        - …



- **Service I/O XSDs**
- **Artifact XSDs**

Traditional Approach: ***Generate Model Into Code***



The Siena Model

Innovator

Now what do I do with all this stuff?

JavaScript

WSDL

HTML

JSPs

XML

Servlets

EJBs

ACL

Lots and Lots of

BPEL

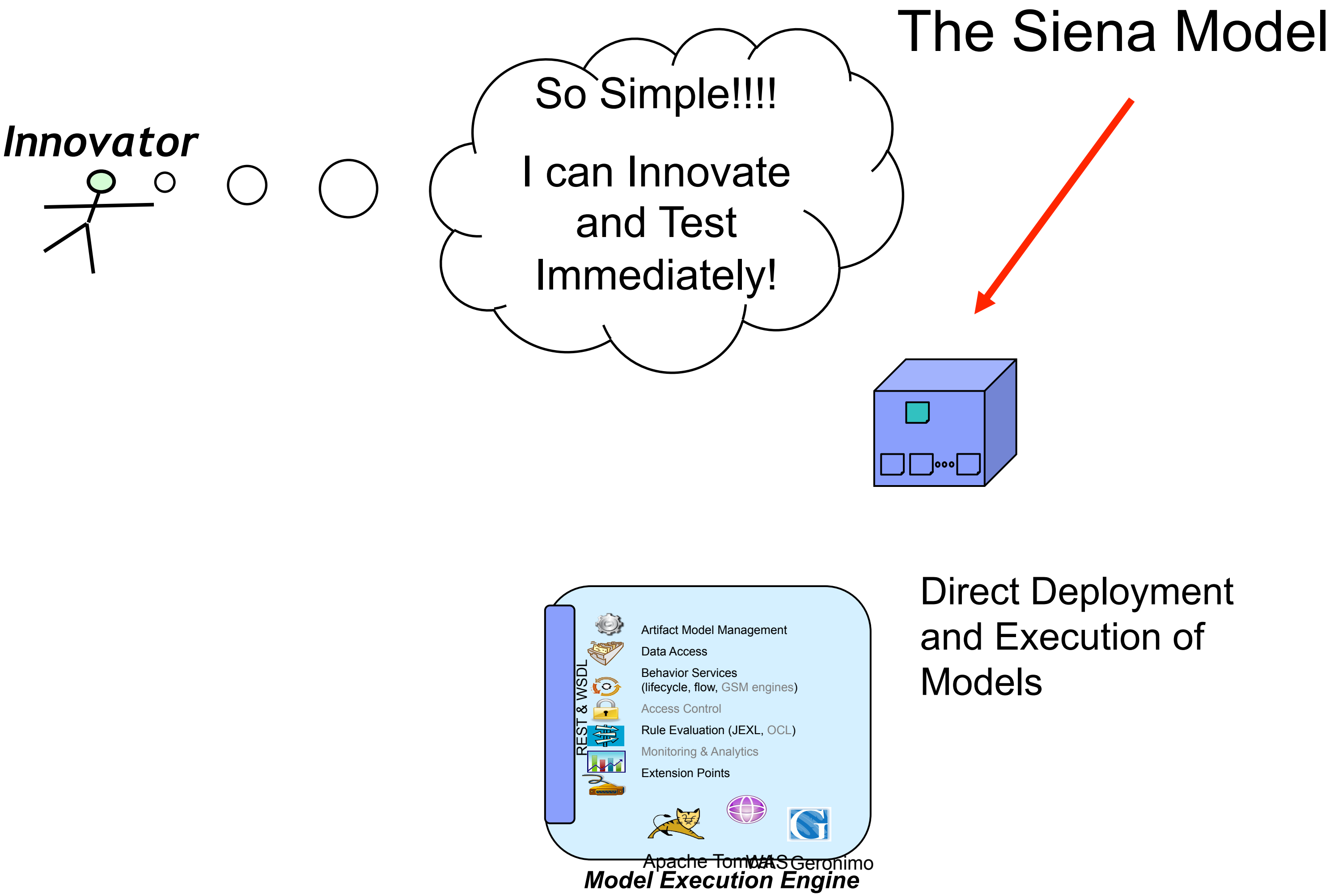
JAVA

XSD

SQL

DDL

Siena Approach: *Direct Deploy and Execute Models*



The Siena Model

Innovator

So Simple!!!!

I can Innovate and Test Immediately!

Artifact Model Management

Data Access

Behavior Services (lifecycle, flow, GSM engines)

Access Control

Rule Evaluation (JEXL, OCL)

Monitoring & Analytics

Extension Points

REST & WSDL

Apache Tomcat

WAS

Geronimo

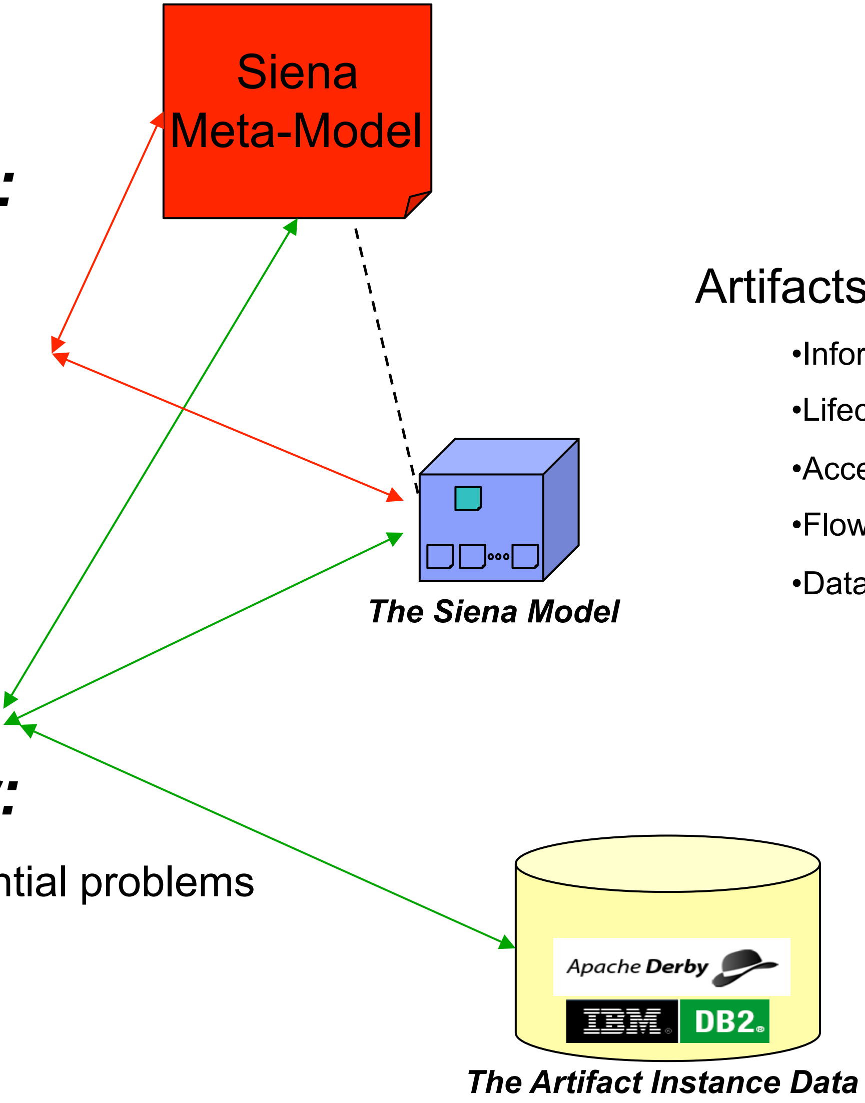
Model Execution Engine

Direct Deployment and Execution of Models

Platform Independent Entity-Centric Model
(Can be used to Reason against)

At Design time look for:

- Life cycle deadlocks
- Flow deadlocks
- Artifact interaction deadlocks



The Siena Model

The Artifact Instance Data

Artifacts

- Information Model
- Lifecycle Model
- Access Control Model
- Flow Model
- Data Access Model

At Runtime time look for:

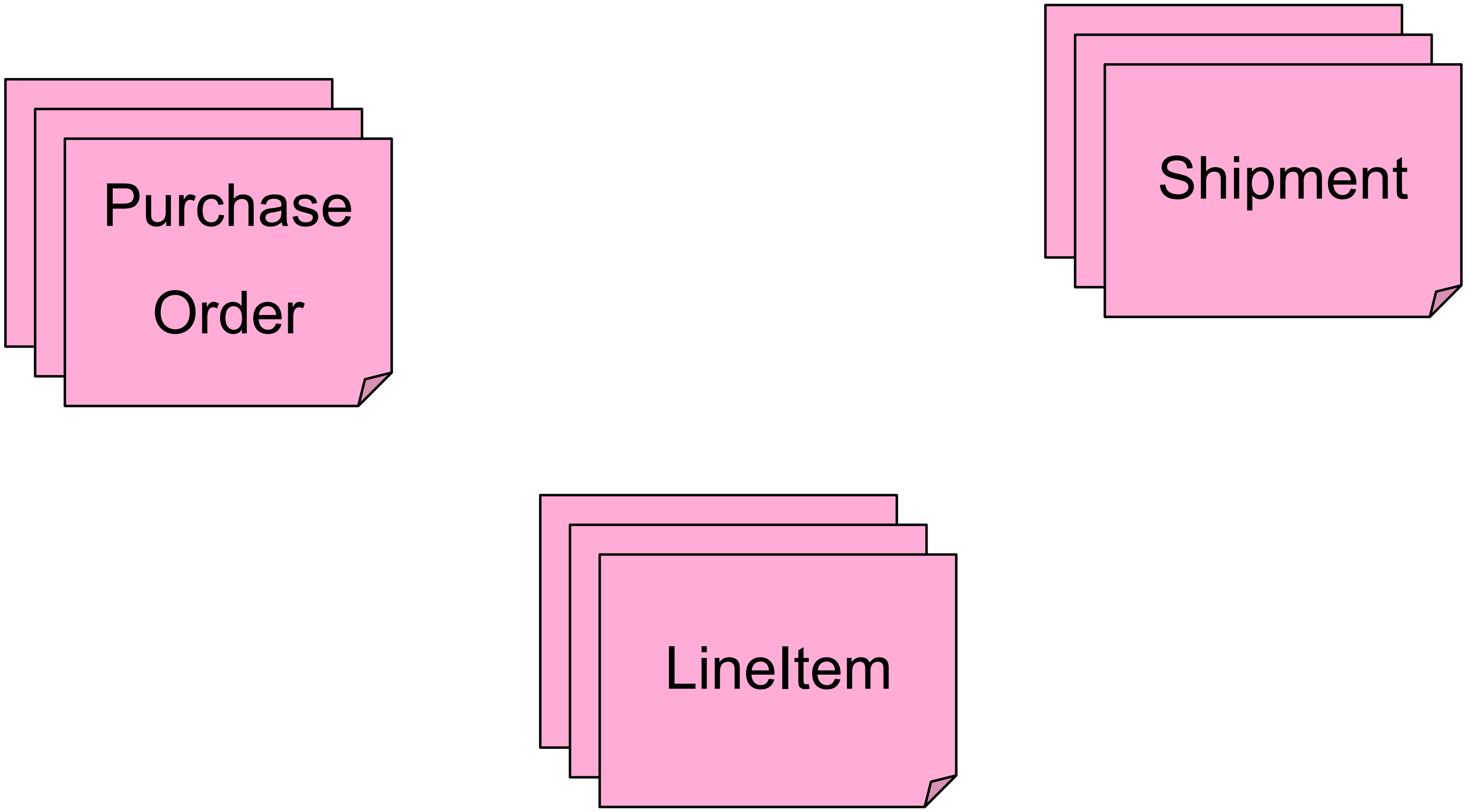
- Instance level forecasting of potential problems

Siena Demo: Example of an Entity-Centric Solution

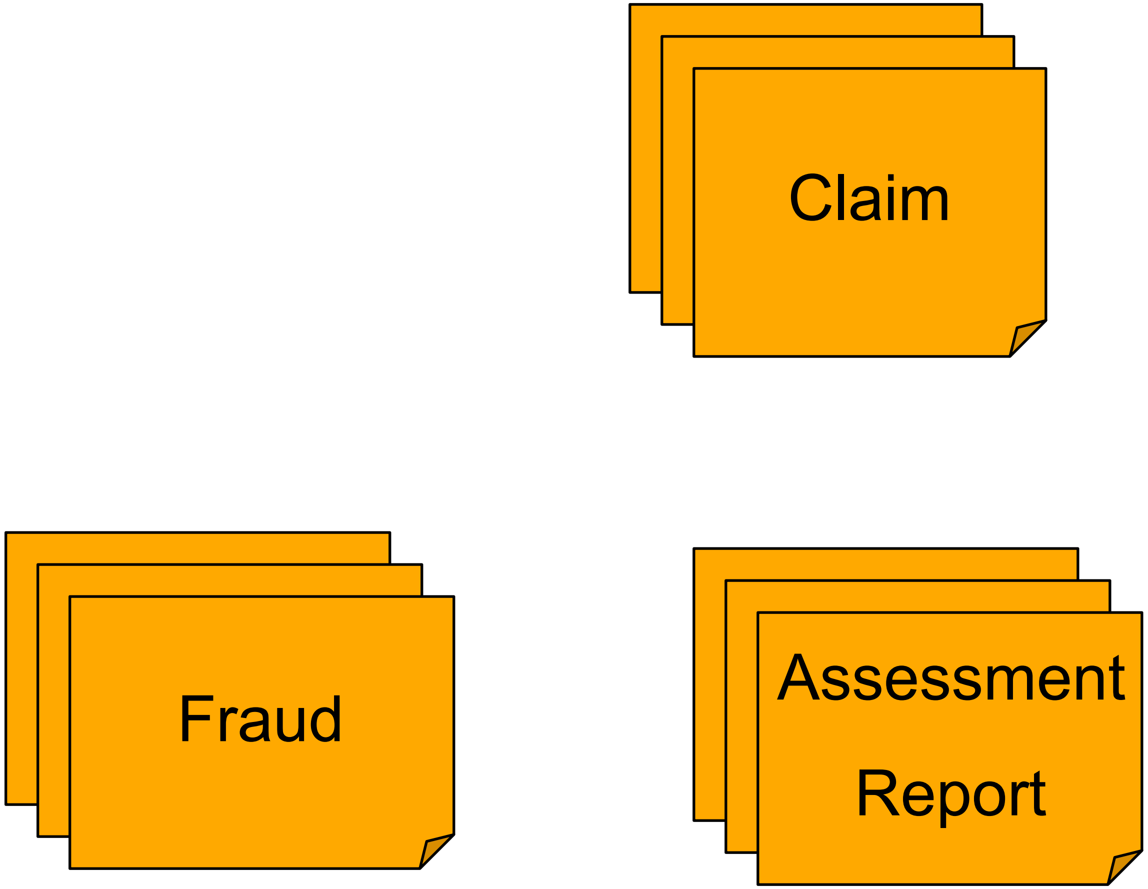
- **Review Hotel Design**
- **Run Hotel Design**

Demo Questions and Answers

Procurement



Insurance

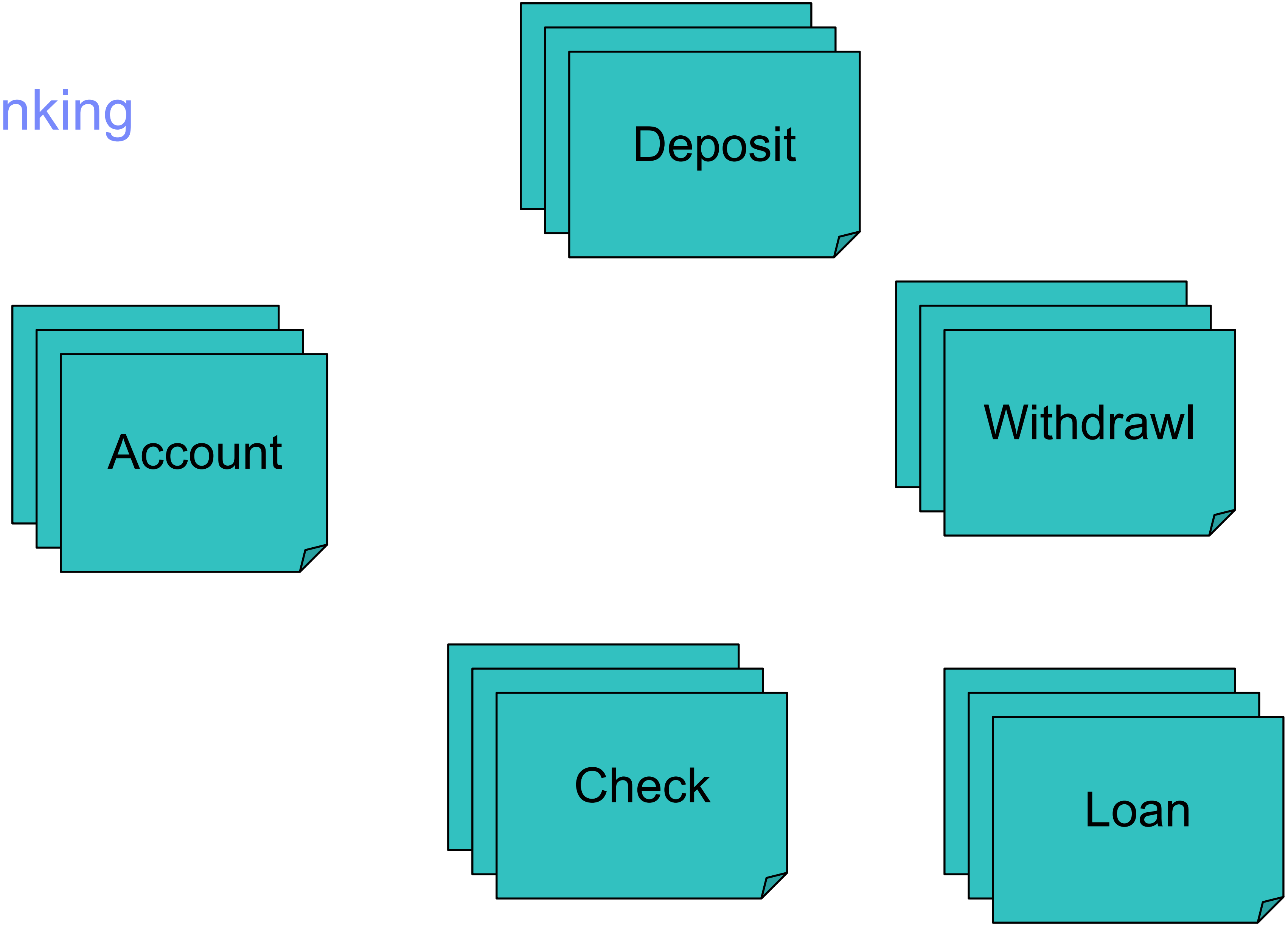


Claim

Fraud

Assessment Report

Banking



Deposit

Account

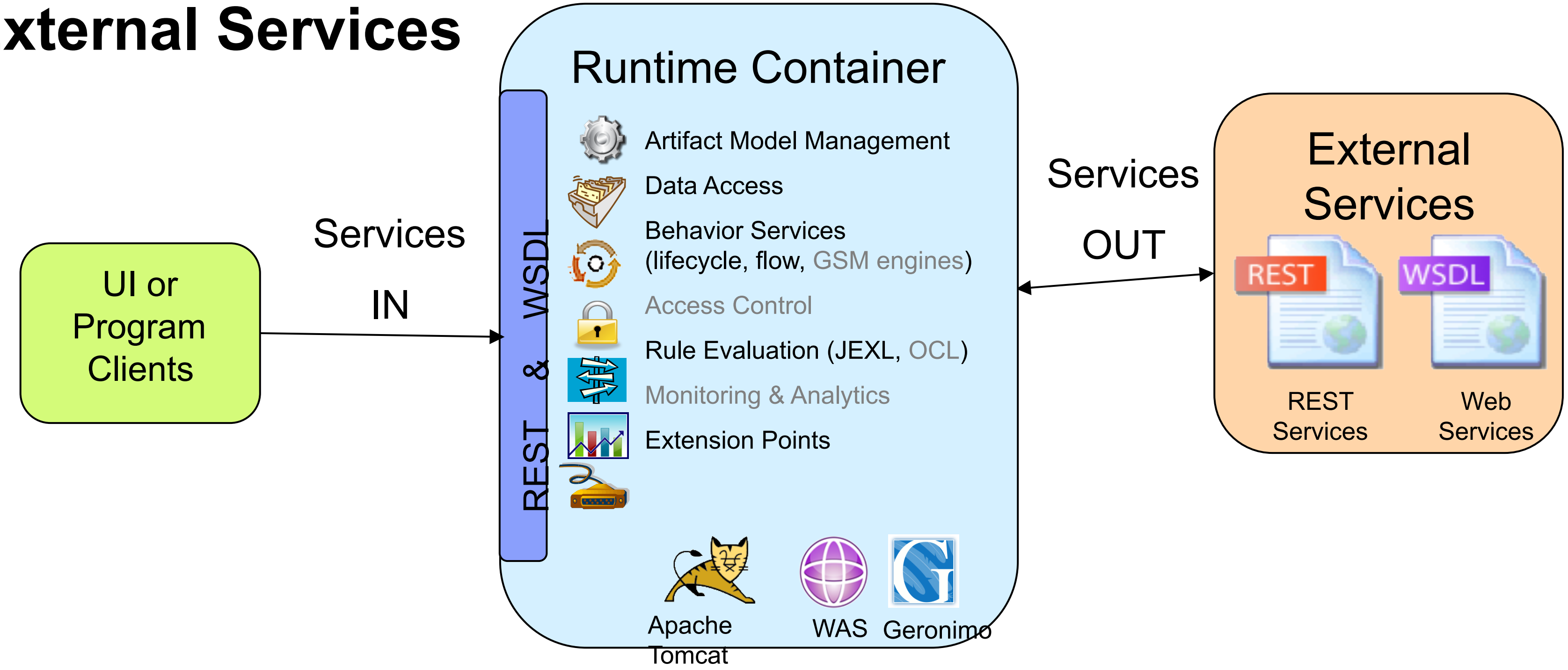
Withdrawl

Check

Loan

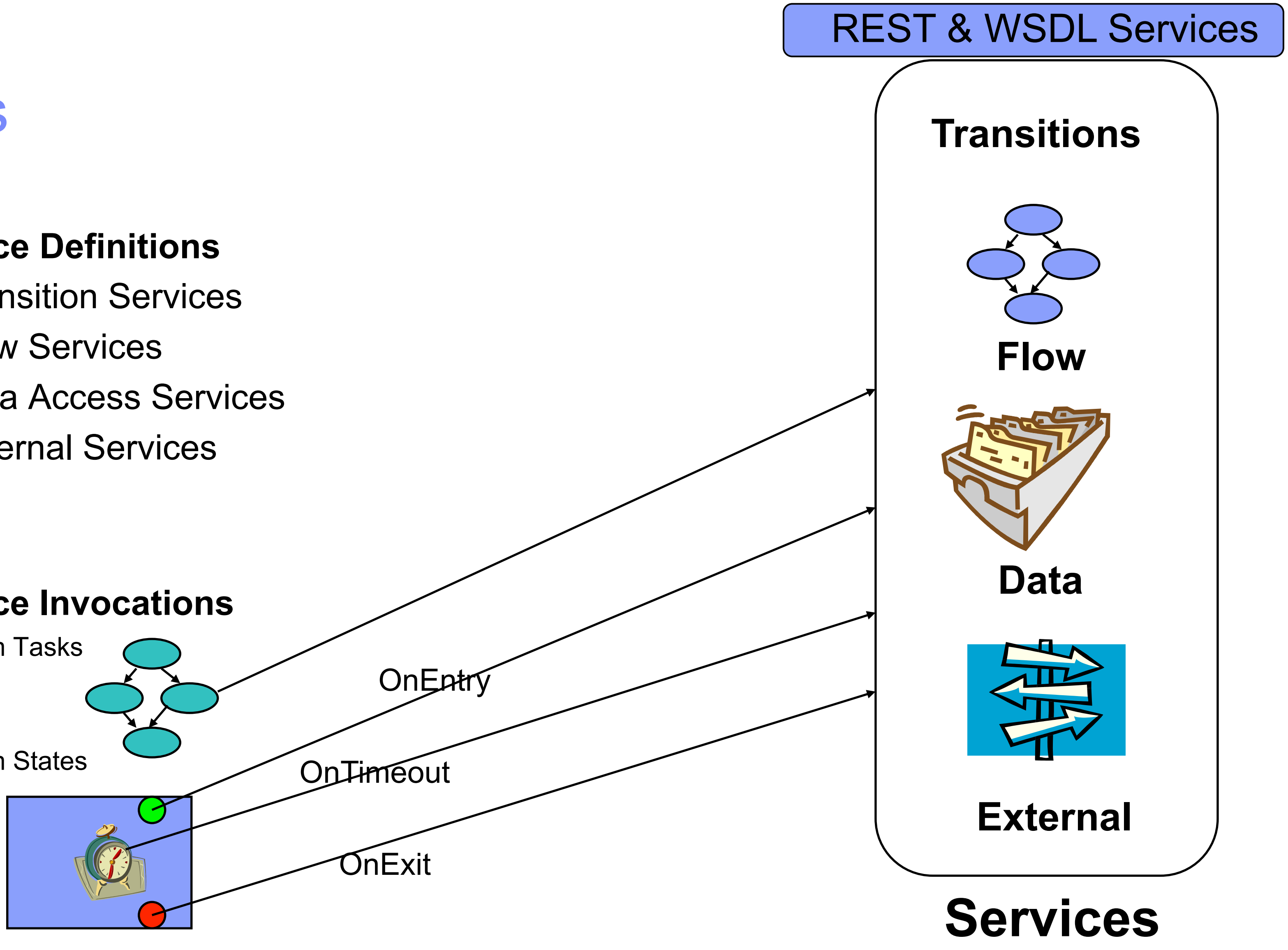
Everything is a service in Siena

- **Data Access**
- **Lifecycle transitions**
- **Flows**
- **External Services**



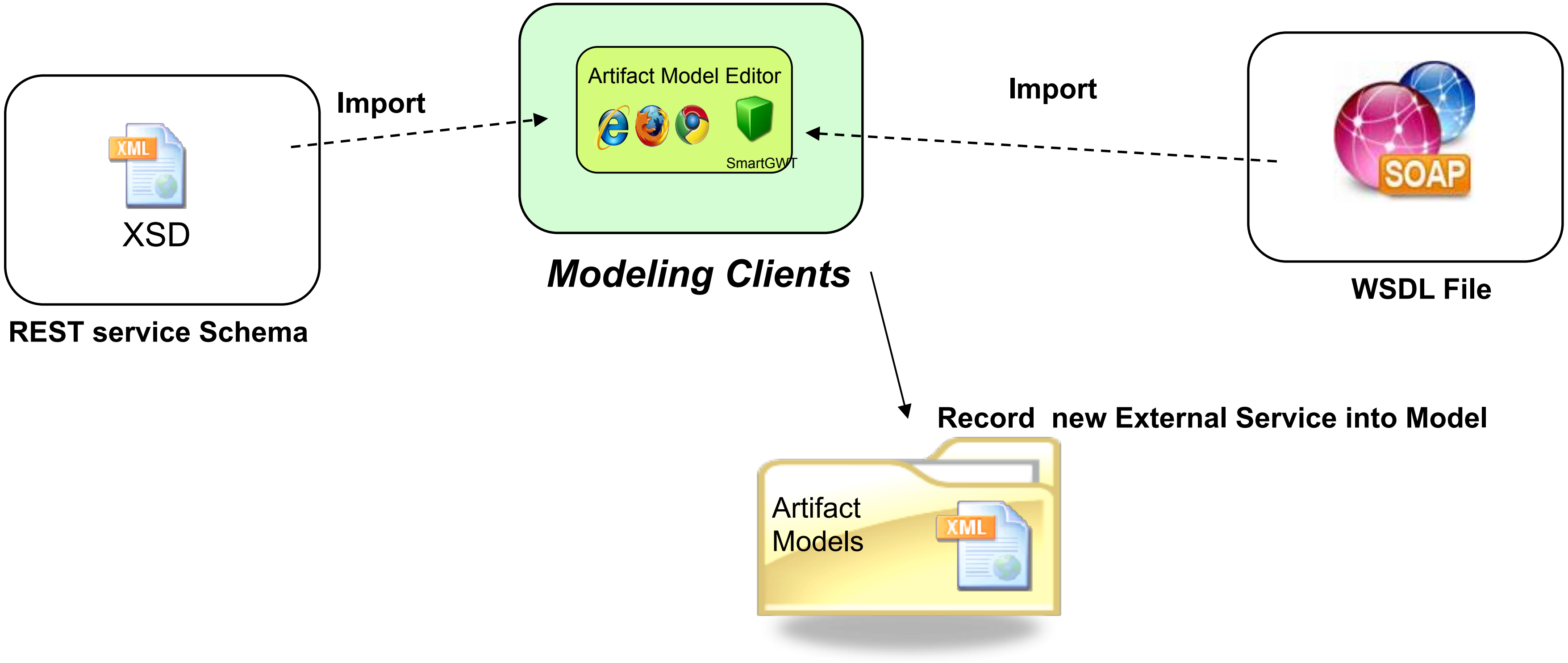
Services

- **Service Definitions**
  - Transition Services
  - Flow Services
  - Data Access Services
  - External Services
- **Service Invocations**
  - From Tasks
  - From States



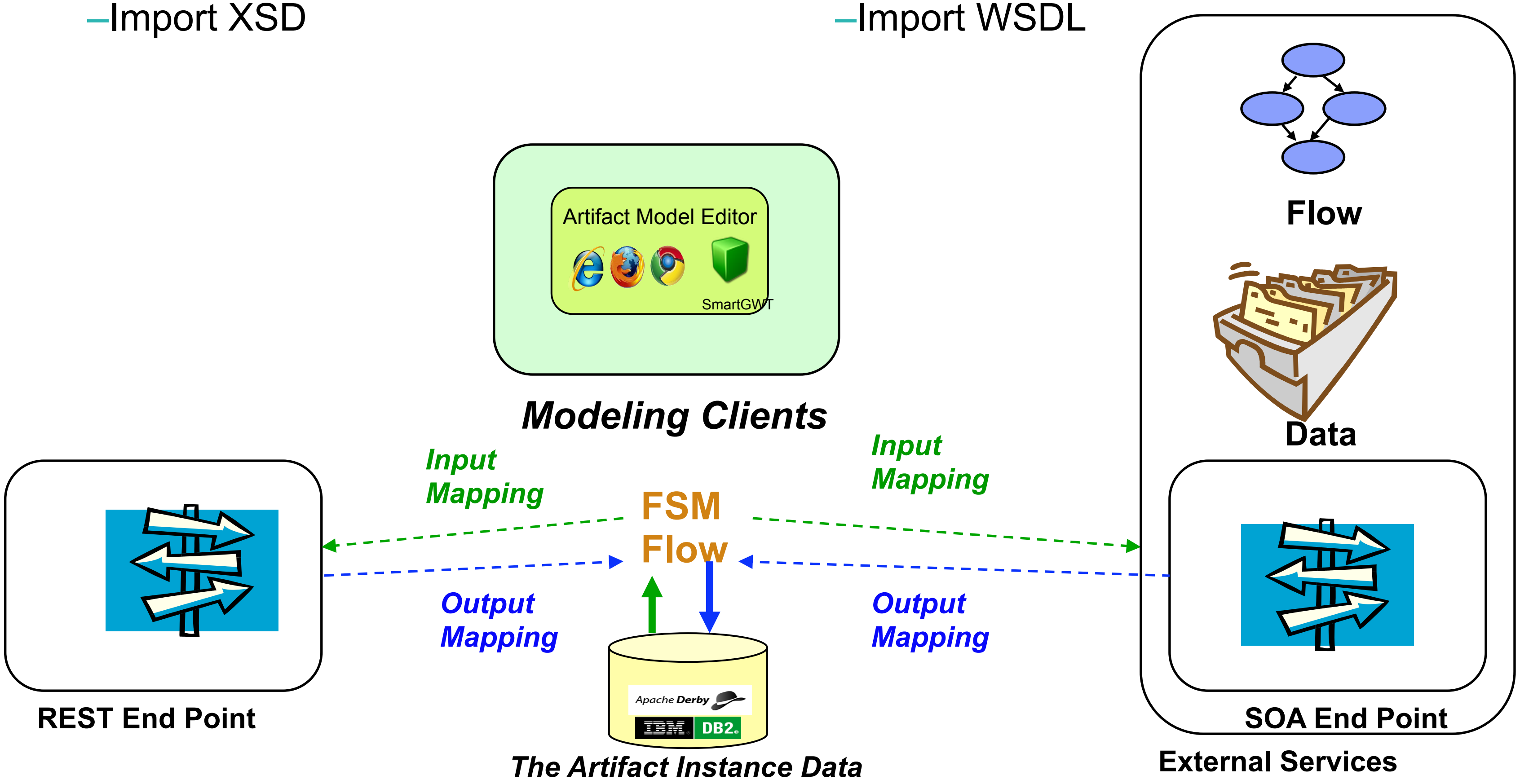
Registering External Services

- **REST**
  - Specify Service End Point URI
  - Import XSD
- **WSDL**
  - Point to Remote WSDL File
  - Import WSDL



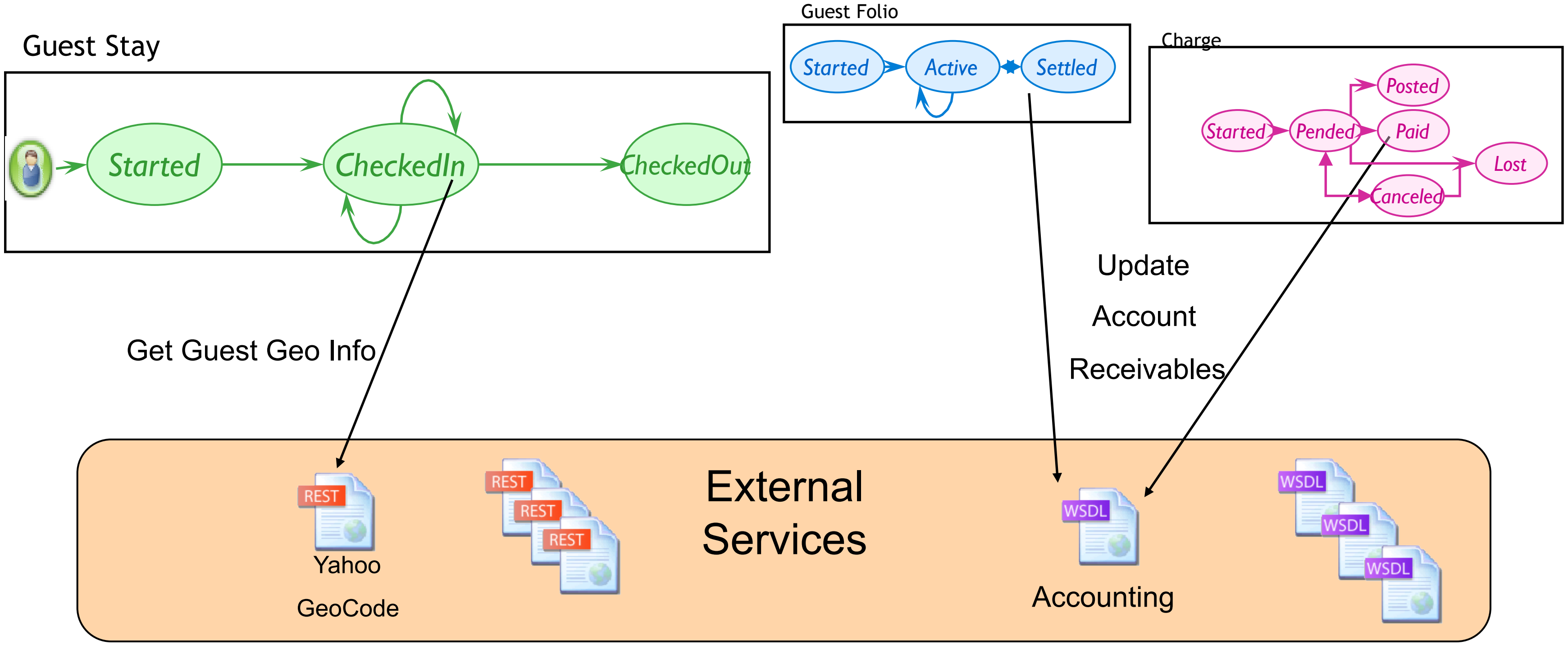
Binding and Mapping External Services

- **REST**
  - –Specify Service End Point URI
  - –Import XSD
- **WSDL**
  - –Point to Remote WSDL File
  - –Import WSDL



Business Entities give context for Service Invocations

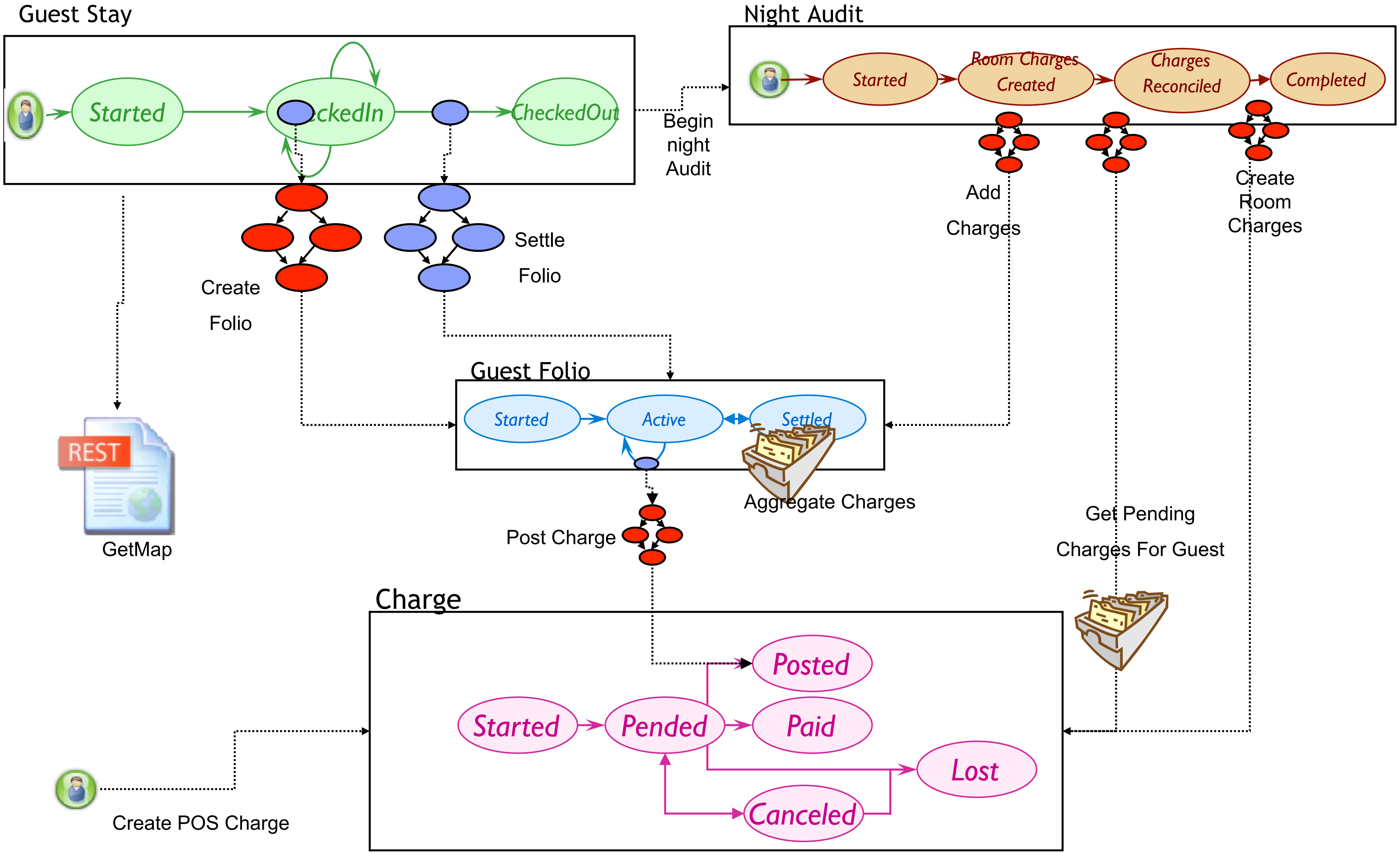
External Service Integration (REST and WSDL)



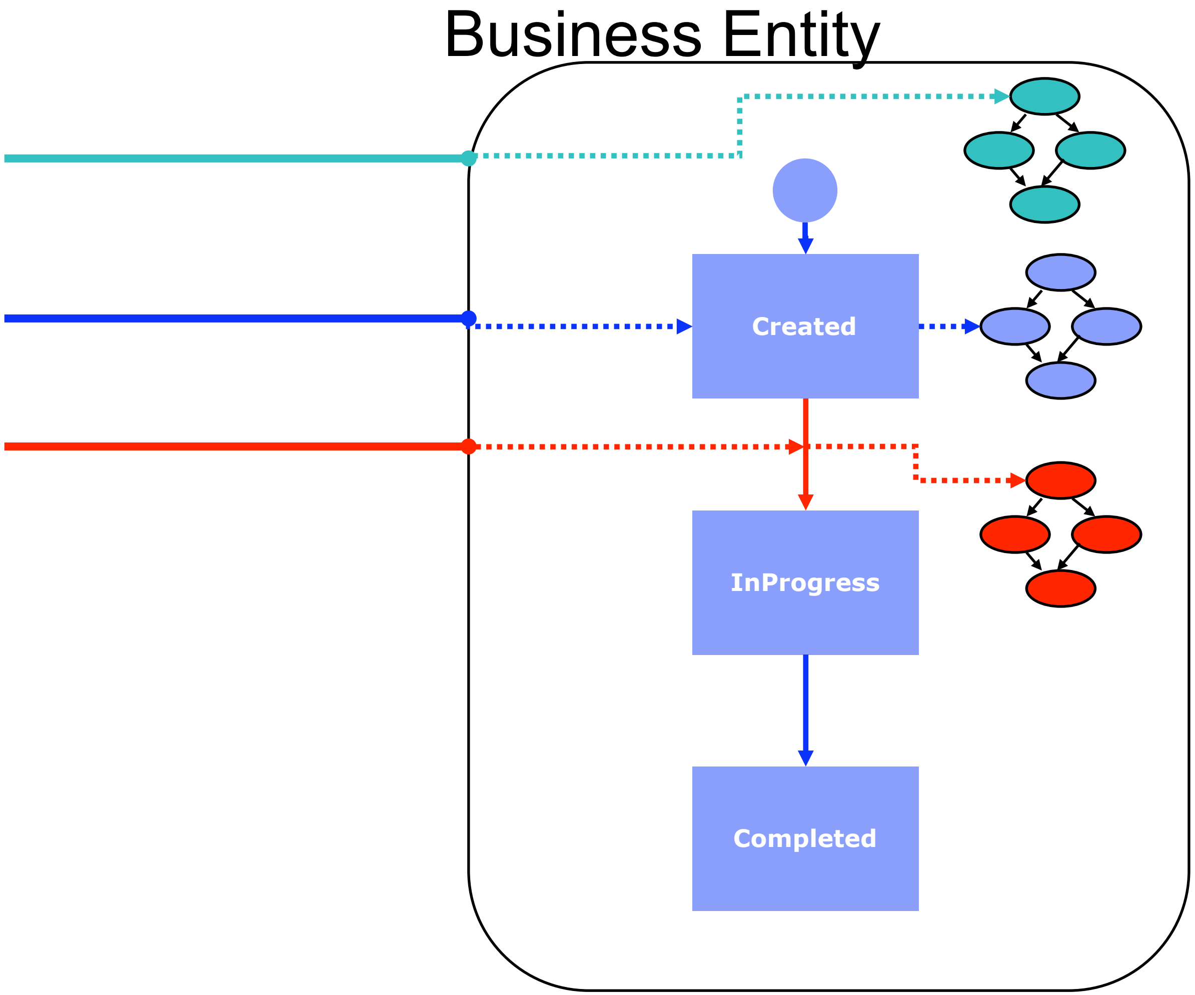
Large Collection of Externals Services Contextualized by Business Entities

Determine Entity Interactions

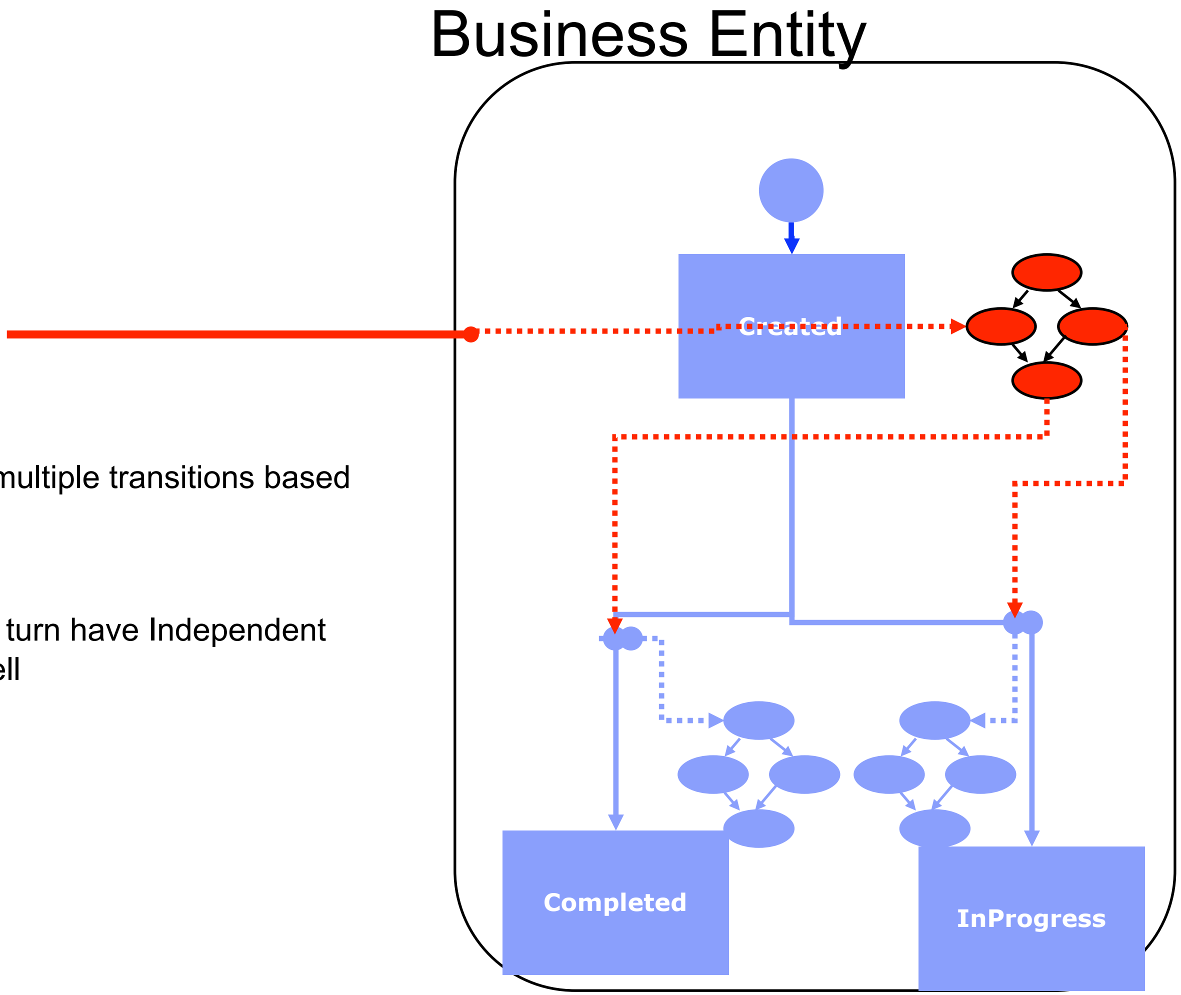
- **Direct link between check in and night audit.**



Basic Flow Patterns

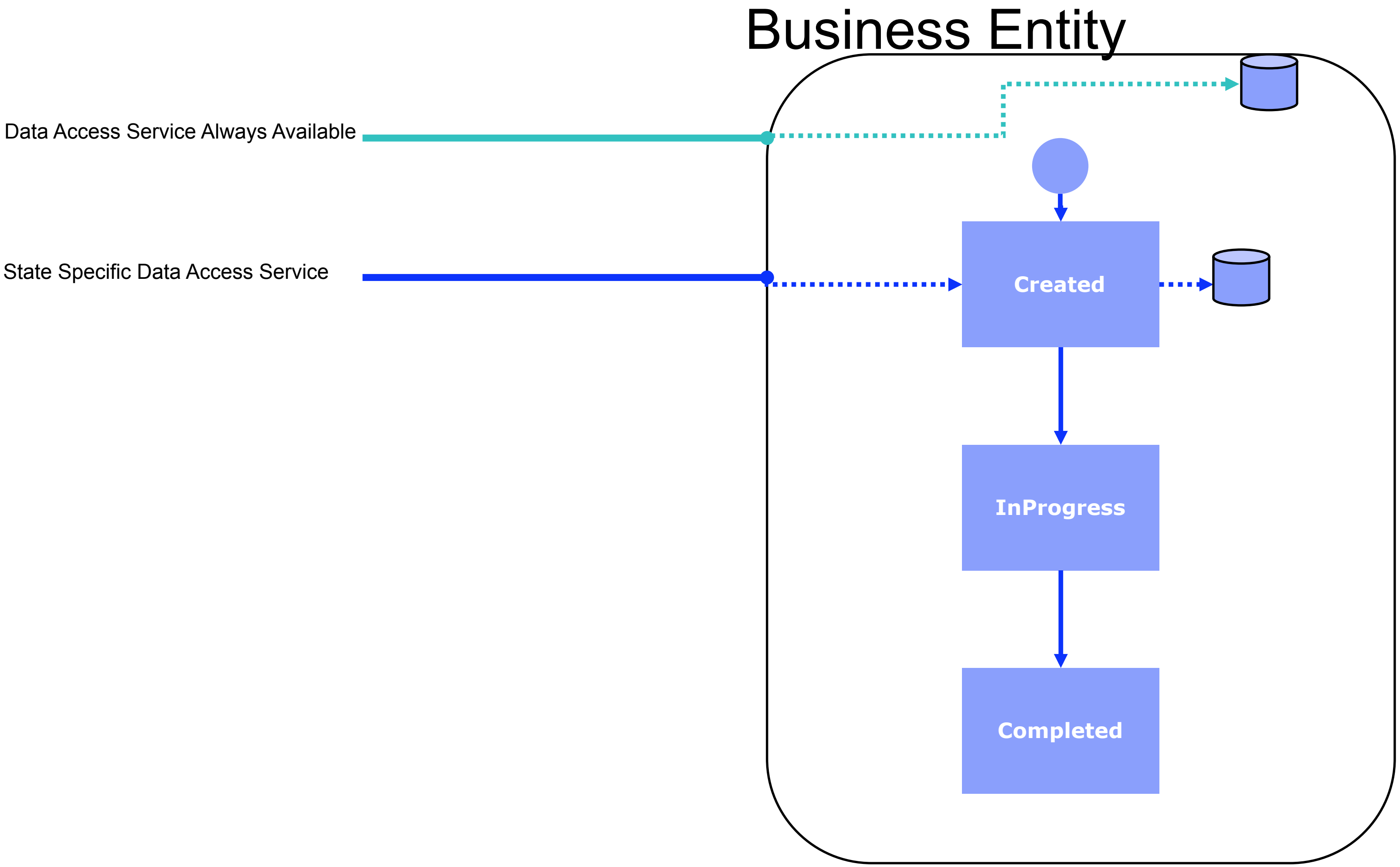


Advance Flow Pattern

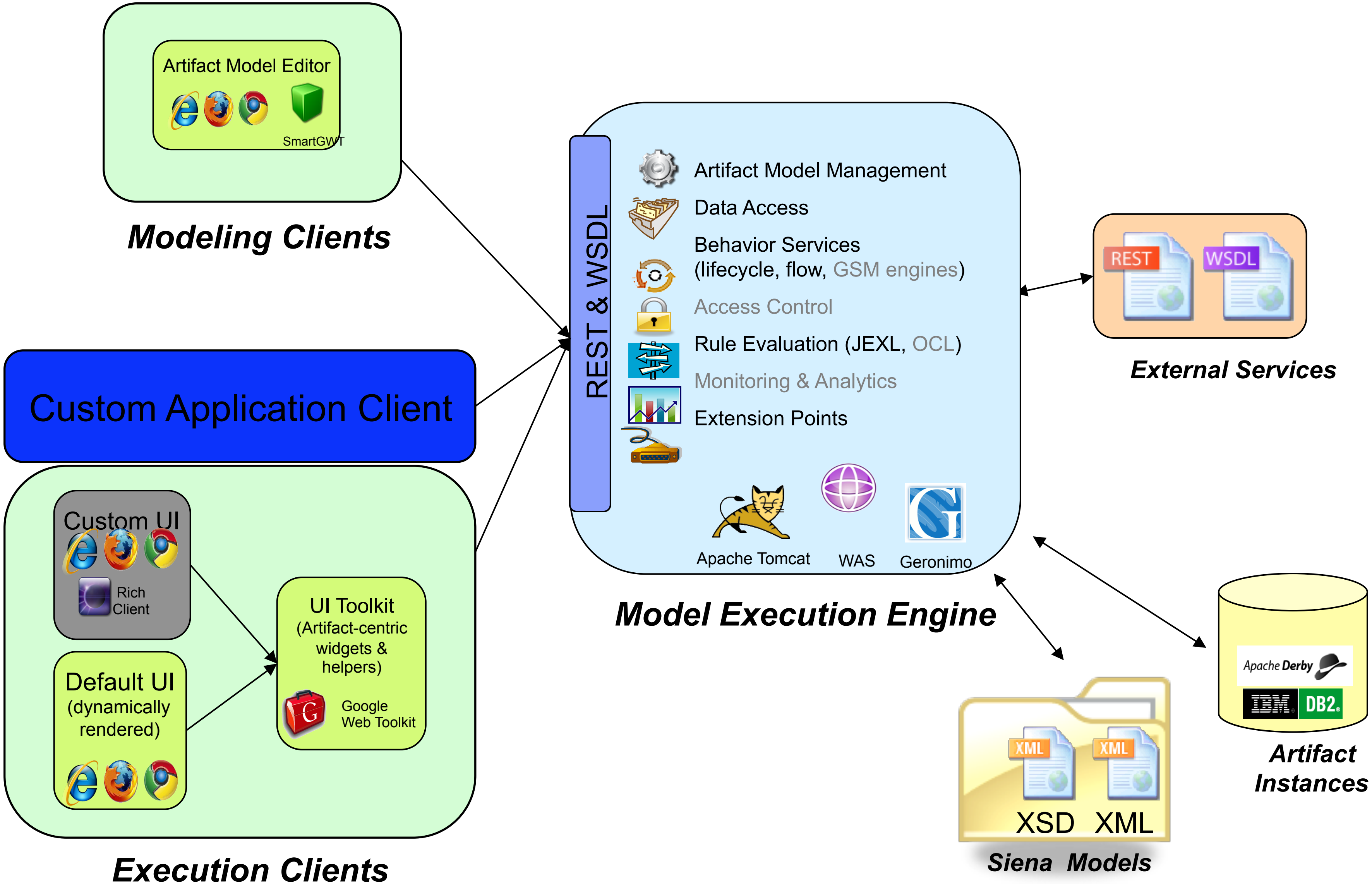


- One Flow can invoke multiple transitions based on Flow outcome
- Each Transition can in turn have Independent Transition Flows as well

Basic Data Access Patterns


Business Entity
Data Access Service Always Available
State Specific Data Access Service
Created
InProgress
Completed

Siena Architecture Diagram



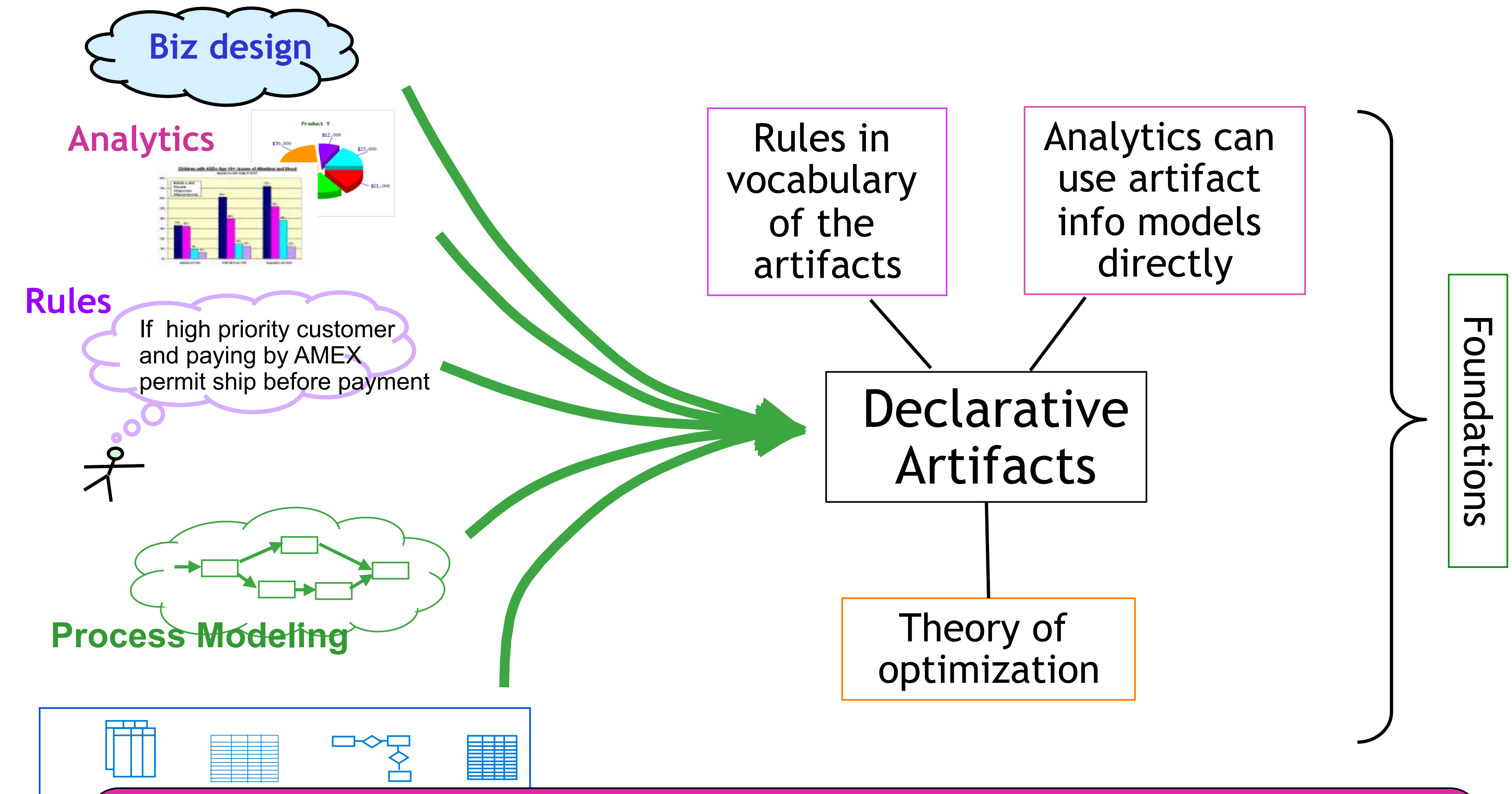
Future Artifact-Centric work

- **Further Siena Web Tooling Features**
- **Optimize Siena Engine**
- **Project ArtiFact ™**
  - Declarative Approach (no wires or transitions)
    - Guards, Stages and Milestones

What is Project ArtiFact™ GSM

- **Hierarchical Units of Work**
  - Units of Work (***Stages***)
    - Launch by Conditions (***Guards***)
    - Completed by Expressions (***Milestones***)

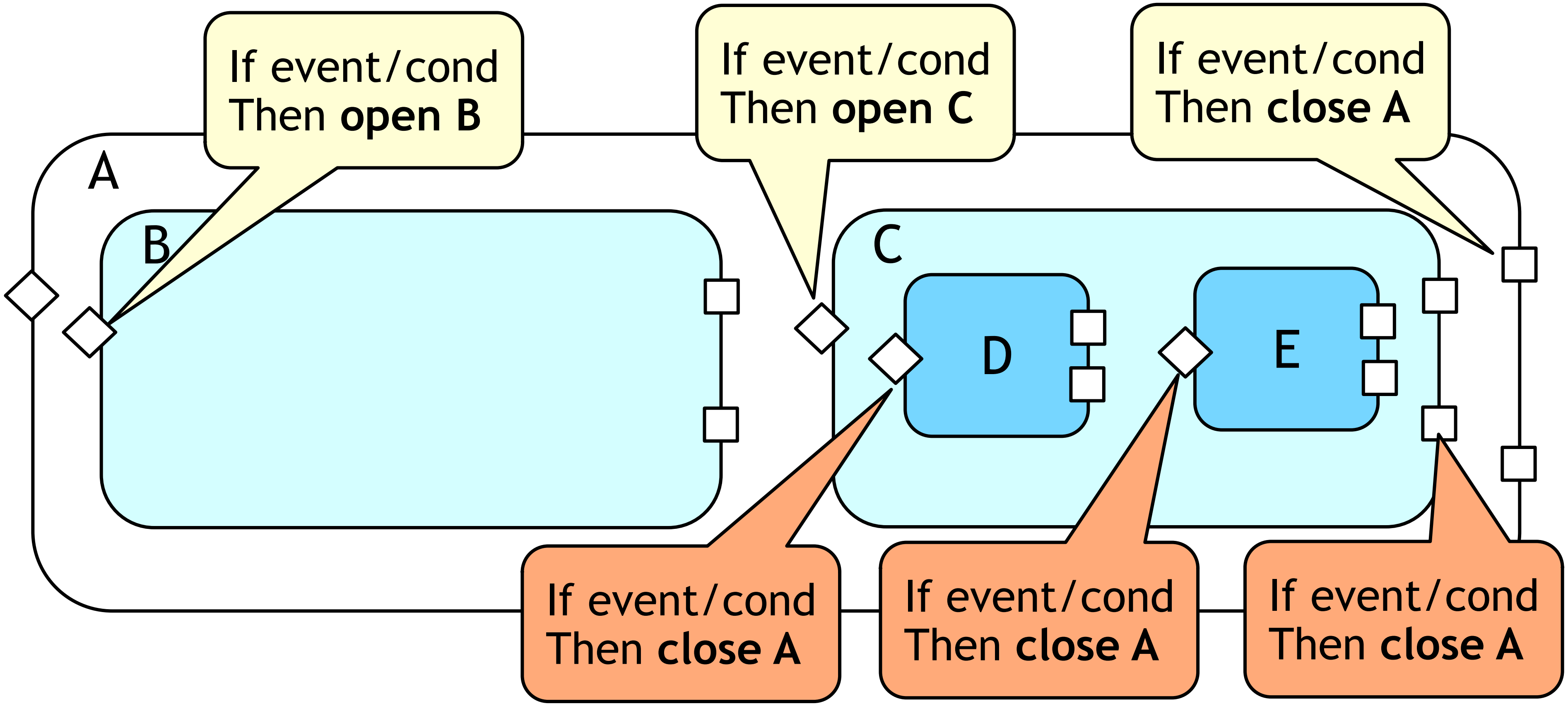
Declarative Artifact-Centric as a unifying basis for future BPM


Biz design
Analytics
Rules
If high priority customer and paying by AMEX permit ship before payment
Process Modeling
Data
Rules in vocabulary of the artifacts
Analytics can use artifact info models directly
Declarative Artifacts
Theory of optimization
Foundations

Declarative Artifacts might play the role for BPM that Relational Model played for Database Mgmt

Hierarchical Stages (Units of Work)

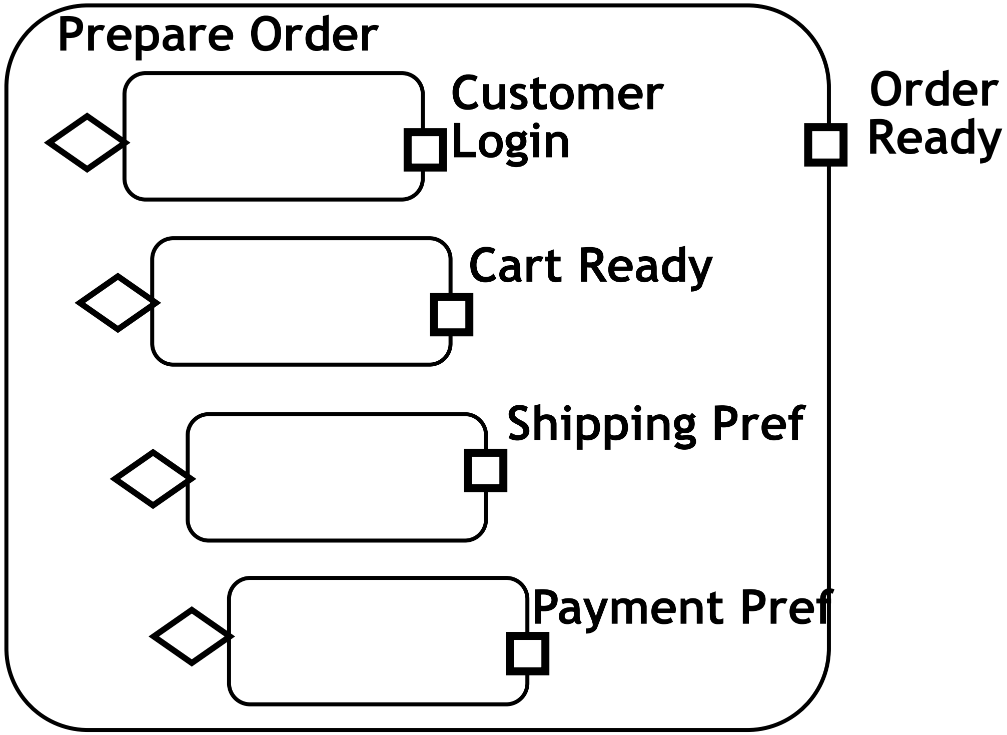
with contextual Rules



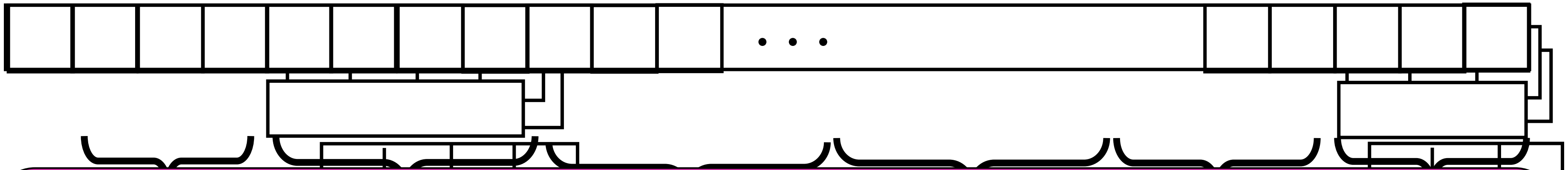
A stage focuses on a natural, small cluster of related rules

More on the “guarded” style for lifecycle specs

- ***Can put a variety of rules / conditions into the “guards”, e.g.,***
  - Can only enter Customer login stage once
  - If you change Cart you must revisit Shipping Pref
  - Cannot enter Payment Pref until either you are logged in or put stuff in Cart



- ***Can vary the guards based on region, customer category, etc.***
  - Variation at any level of hierarchy



Flow charts and state machines useful in some contexts; “Ad hoc” style useful in other contexts

Client Toolkit: Siena API Façade

(***REST****ful* Siena)

- ***SienaServiceClient*** API
  - Generic RESTful API to call Siena
  - Support for XML Input, XML Output, JSON Input, JSON Output
  - API:
    - SienaServiceClient sienaClient = new SienaServiceClient();
      - Restful Service Façade
    - sienaClient.invokeXml();
      - Invoke Services (flow services, data services, transition services)
    - sienaClient.retrieveListXml();
      - Retrieve Artifact Instance Lists
    - sienaClient.retrieveXml();
      - Retrieve a single Artifact Instance
    - sienaClient.saveXml();
      - Save a single Artifact Instance

Inspect Code: using eclipse

```
static String  appName = "ClientTest";
static String  dataItemId = "MyArtifact";
static String  serviceId = "MyArtifact-ANY-to-Created-0Transition";
static String  inProgressServiceId = "MyArtifact-Created-to-InProgress-0Transition";

String ArtifactXML = "<MyArtifact
                        attribute1='Via Labicana' attribute2='Roma' attribute3='Terry' attribute4='Heath'>
                      </MyArtifact>";
            //  Make a New Client
            SienaServiceClient client = new SienaServiceClient("http://localhost:8080/SienaWeb", "defaultAdmin", null);

            // Invoke Any to Created
            String invokeXmlOutputMessage = client.invokeXml(appName,serviceId, URLEncoder.encode(ArtifactXML));

            // Extract newly created ID from new Instance
            String id = parseIDFromXML( invokeXmlOutputMessage );

            // Invoke Created to InProgress
            String inProgInputXML = "<MyArtifact ID='" + id + "' />";
            String inProgOutputXML = client.invokeXml(appName,inProgressServiceId, URLEncoder.encode(inProgInputXML));
```

Run Example Client from Eclipse

- **Jump to IDE**
- **RUN**

Client Toolkit: Siena API Façade

(***REST****ful* Siena)

- ***WSDL Siena***
  - ***Solution Specific WSDL files***
    - Generated into deployed solution
    - Use your favorite IDE to bind to WSDL files and invoke
    - Generate JavaProxy Web Service Client
    - Begin to Invoke WSDL Operations onto the Solution Specific Artifacts

Lets now Inspect the model Using an XML Editor

Explore the Development Environment in Eclipse

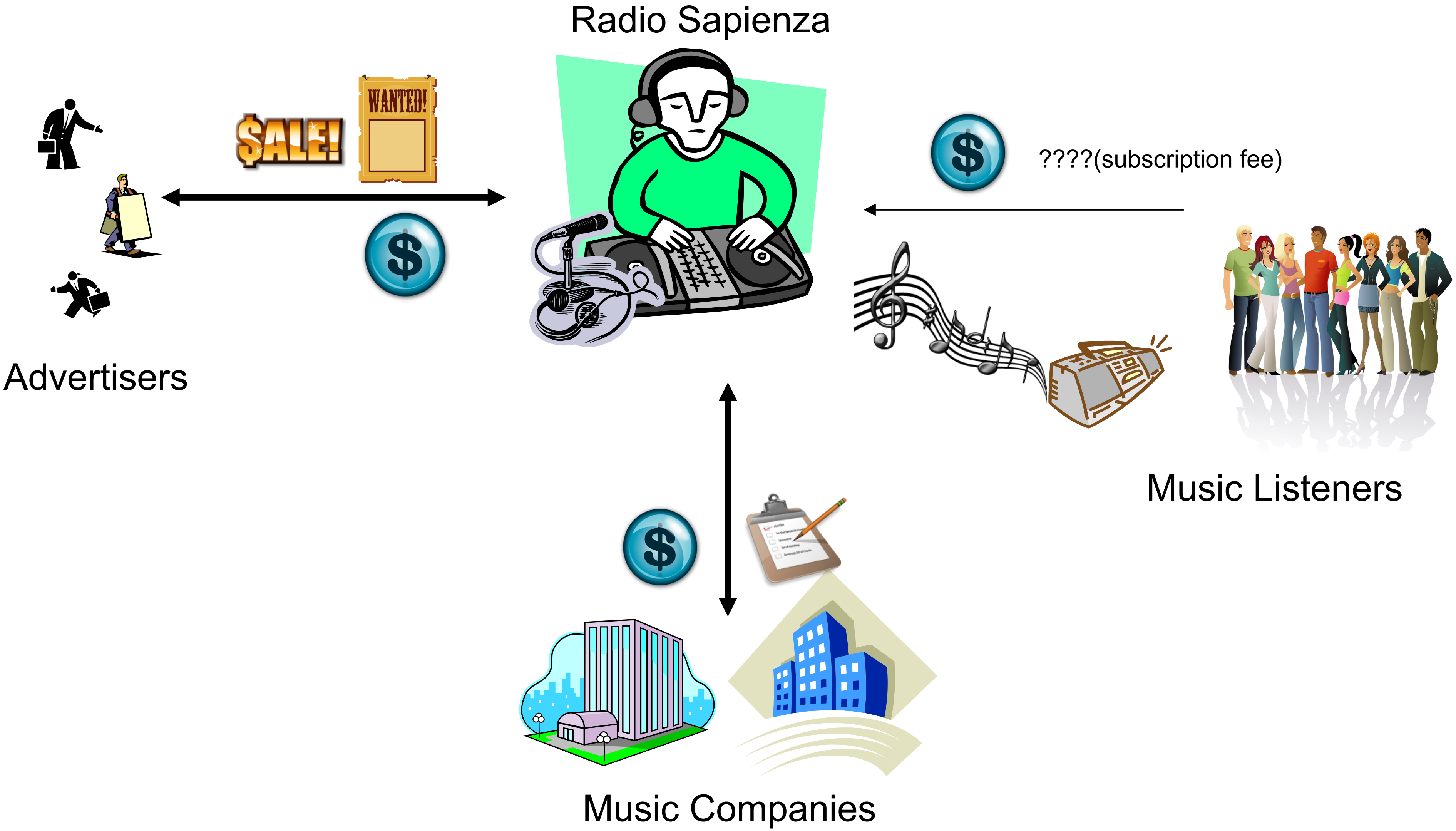
Artifact Relationship Patterns

- **(One to One)**
  - –Insurance Claim can related to 1 Fraud
- **(One to Many)**
  - –***Parent / Child***
    - Purchase Order
      - –Line Items
- **(Many To Many)**
  - –***Purchase Order***
    - Each Purchase Order can be delivered in 1 or more shipments
  - –***Shipment***
    - Each shipment can contain Line Items from different Purchase Orders

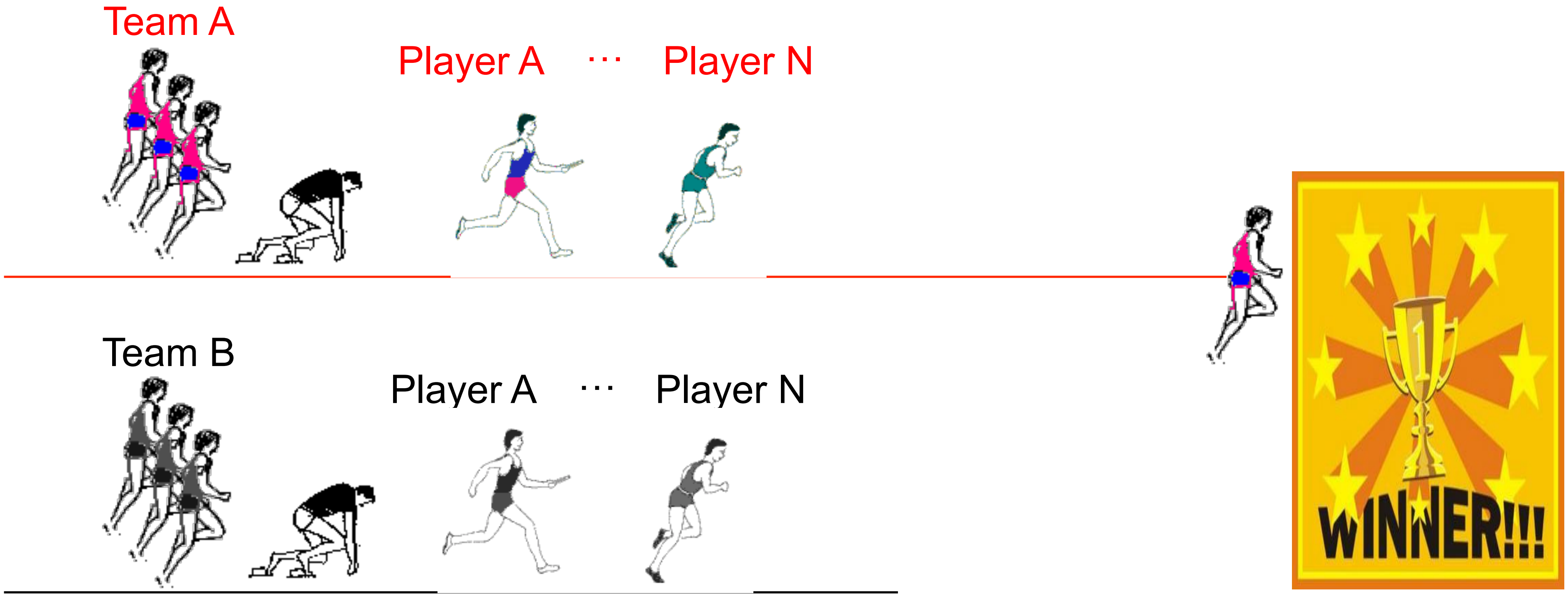
Other Siena Examples

- ***More Siena Examples (Patrizia and Alessio)***
  - –Radio Sapienza
  - –Relay Race
  - –Color Bricks
  - –Clinical

Radio Sapienza Overview (Patrizia and Alessio)



Relay Race Overview (Patrizia and Alessio)



- All Players Run at Random Speeds
- Siena Controls Relay Race Servlets/External Services

CLINIC

- Manages information about the examinations: data of patients, description of the reports, admissions to a ward.
- Manages the ambulances: external services to find destination address and to visualize the map.

COLOR BRICKS

Columns: 4

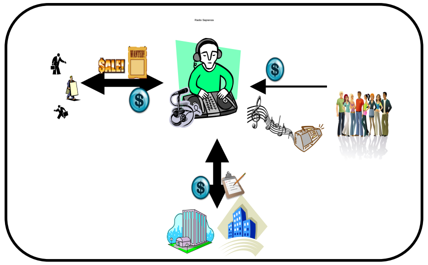
Rows: 4

Cells: 10

🟧	🟦	🟧	🟧
🟧		🟦	
🟦	🟧		
		🟦	🟧

- **Plays a game respecting the constraints.**
- **The user can choose the number of cells and the dimension of the matrix.**
- **Purpose: Siena is able to manage a big amount of instances.**

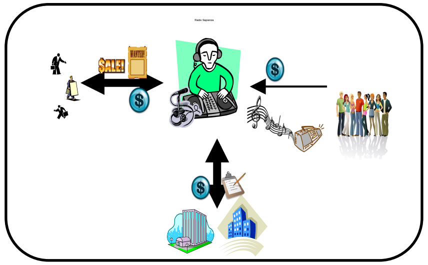
RADIO SAPIENZA ARTIFACTS



RadioSapienza

- PLAYLIST
- TRACK
- PLAYER

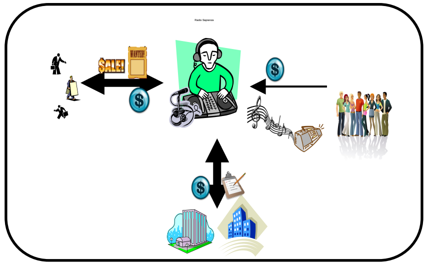
Information Model: PLAYLIST



RadioSapienza

- ***Name*** (string):
  - name of the playlist.
- ***DurationTot*** (long):
  - total duration of the playlist.
- ***PlayerID*** (long):
  - ID of the player that is playing the playlist.
- ***TrackList*** (TypeTrack):
  - list of tracks that compose the playlist.
- ***TrackPlayed*** (TypeTrack):
  - informations of the track that is actually played.

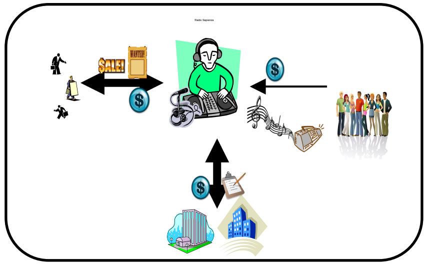
Information Model: TRACK



RadioSapienza

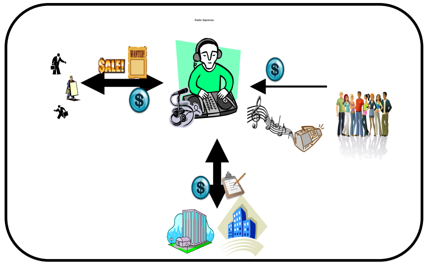
- ***TempPlaylistID*** (long):
  - – ID of the playlist that is playing the track.
- ***StartTime*** (dateTime):
  - – date and time in which the track is played
- ***PauseTime*** (dateTime)
- ***ResumeTime*** (dateTime)
- ***RemainingDuration*** (long):
  - – remaining duration of the track after a “resume” action.
- ***TrackInfo*** (TypeTrack):
  - informations of the track.

Information Model: PLAYER



RadioSapienza

- ***NumberTracks*** (int):
  - Number of the tracks played.
- ***PlaylistID*** (long):
  - ID of the playlist that the player is playing.

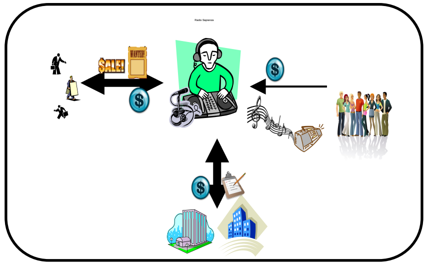


RadioSapienza

EXTERNAL SERVICE: BrowseAmp

- **WinAmp is a media player.**
- **It is controlled by the plugin** “BrowseAmp”**.**
- **BrowseAmp offers a RESTful service**
  - Allows us to control WinAmp with simply URLs
    - Play
    - Stop
    - Pause
    - Resume

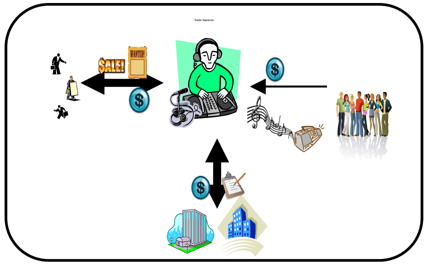
OTHER SERVICES: ODDCAST E ICECAST



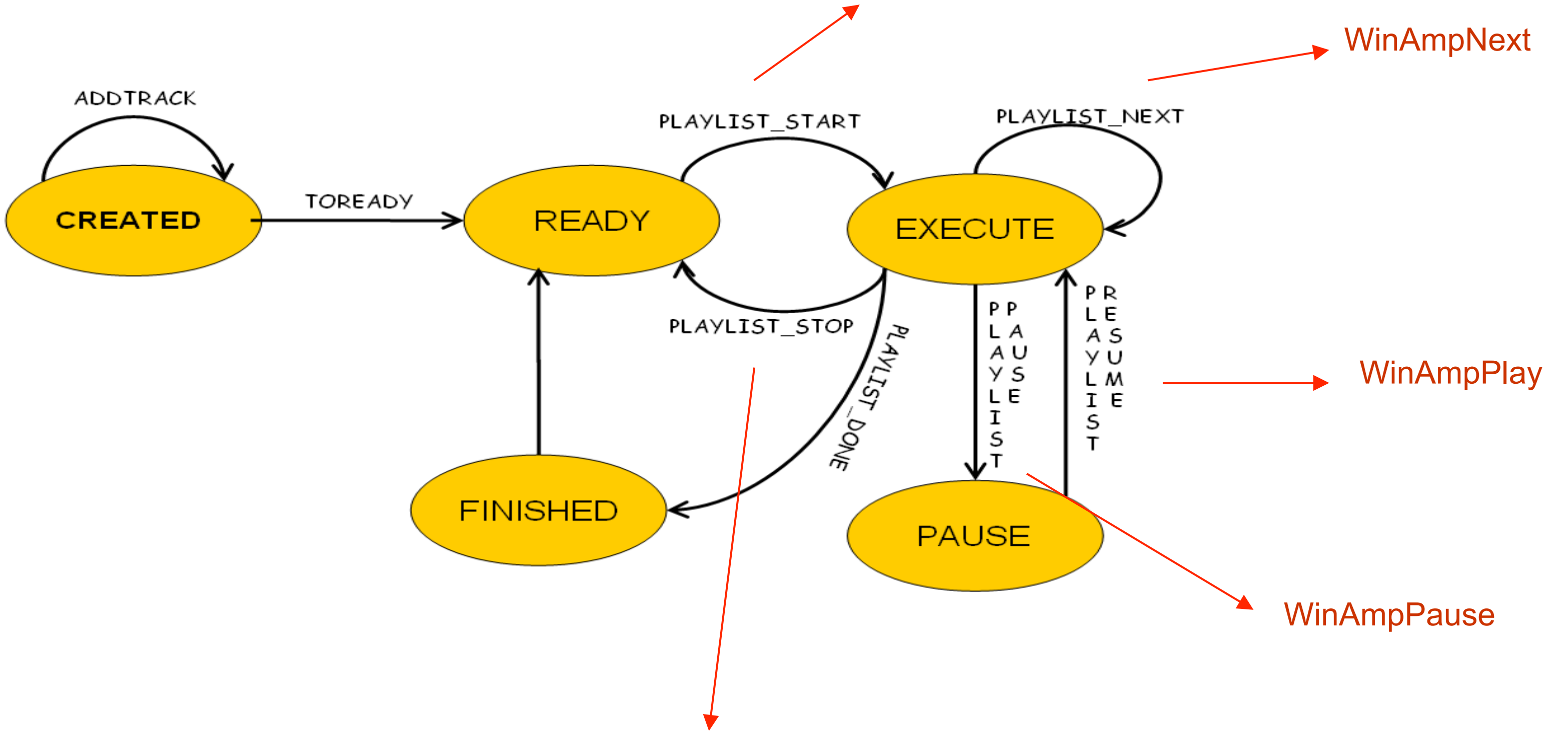
RadioSapienza

- **We use two free softwares in order to simulate a radio station on internet.**
- Oddcast **sends the parameters to WinAmp that it is playing on the port 8002.**
- IceCast **broadcasts on internet the stream of data that arrives on that port.**
- **The users can listen the playlist using the link: http://151.100.59.92:8002/Radiosapienza.m3u (address of the server in which all the applications run).**

State Diagram: PLAYLIST



RadioSapienza



WinAmpLoadPlayList

WinAmpNext

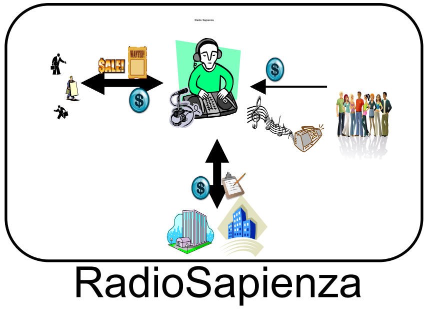
WinAmpPlay

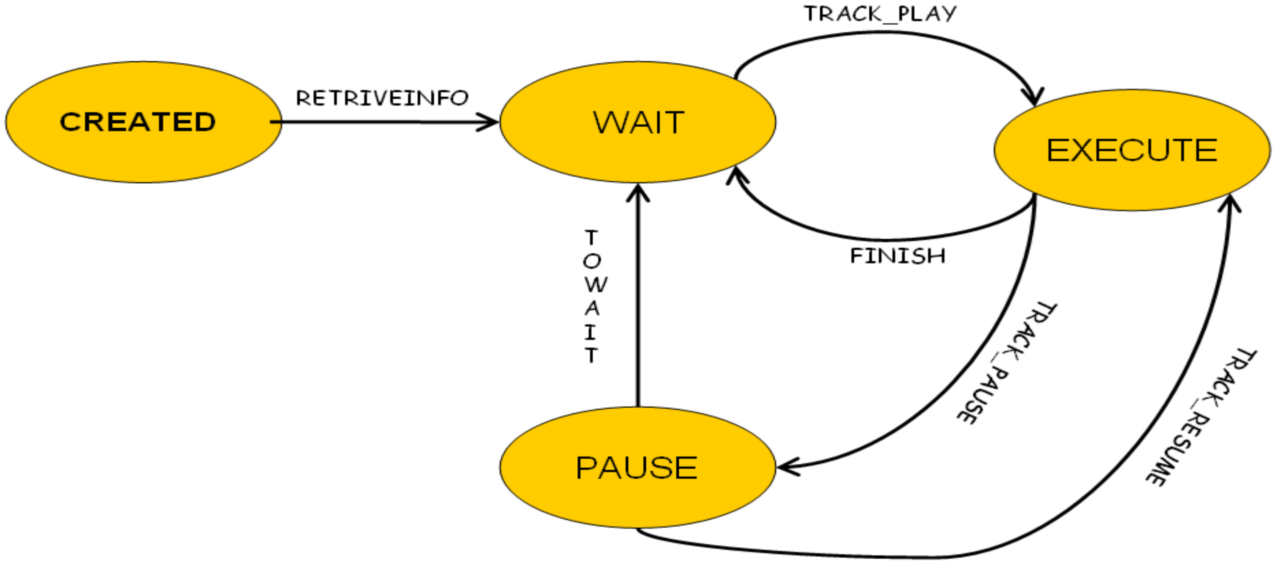
WinAmpPause

WinAmpStop

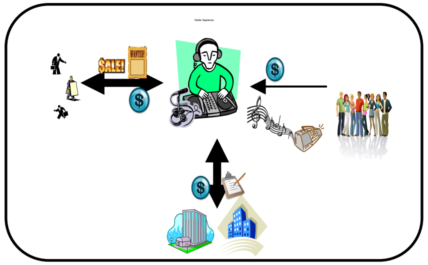
WinAmpClear

State Diagram: TRACK

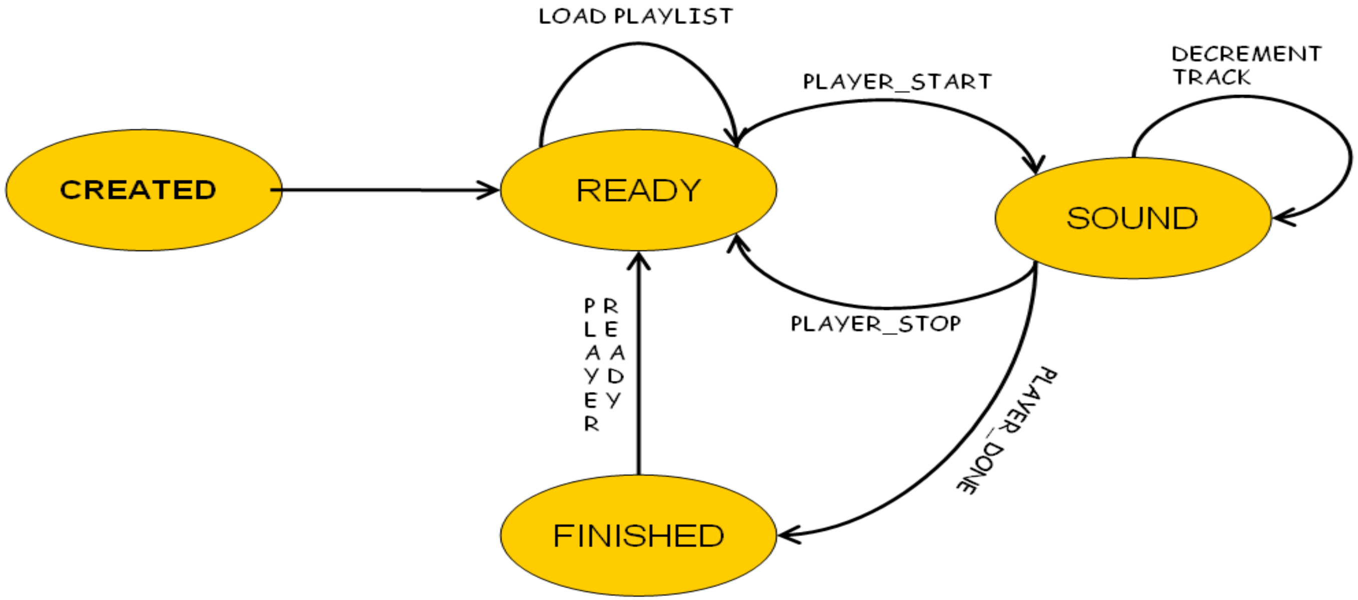




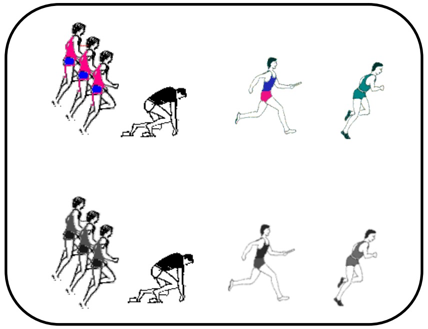
State Diagram: PLAYER



RadioSapienza



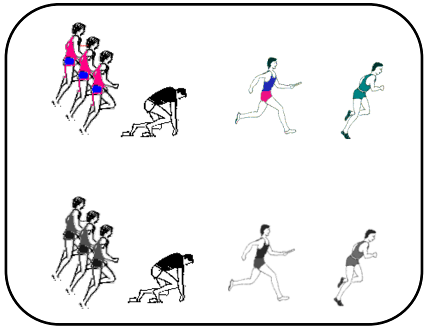
RELAYRACE: ARTIFACTS



Relay Race

- PLAYER
- TEAM
- RACE

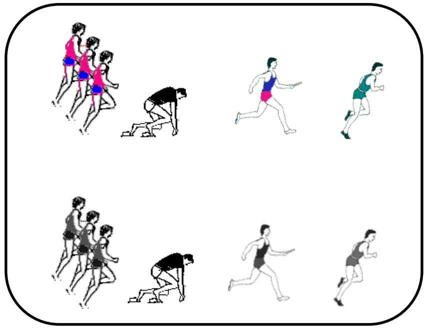
Information Model: PLAYER



Relay Race

- ***Name*** (String):
  - Player’s name.
- ***Speed*** (Float):
  - Player’s velocity.
- ***Time*** (Long):
  - Space / Speed (m/s).
- ***TeamID*** (Long):
  - ID of the player’s team.

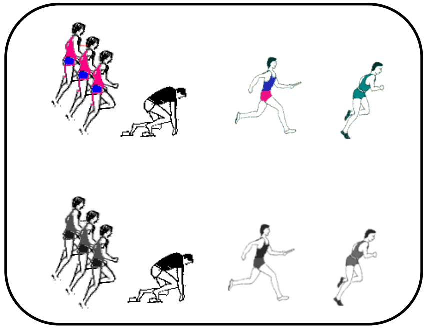
Information Model: TEAM



Relay Race

- ***Name*** (String):
  - Name of the Team.
- ***TotalTime*** (Long):
  - Time spent to finish the race.
- ***RaceID*** (Long):
  - ID of the race in which the team is playing.
- ***PlayerList*** (PlayerType):
  - List of players of the team.

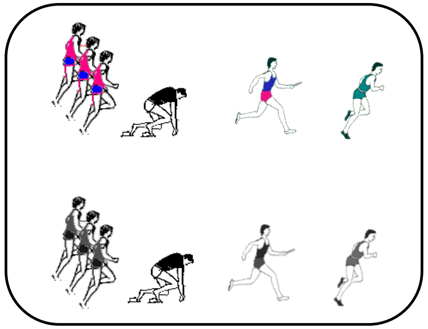
Information Model: RACE



Relay Race

- ***Name*** (String):
  - Name of the Race.
- ***TeamList*** (TeamType):
  - List of team that takes part in the race.
- ***Results*** (Results):
  - Arrival ranking of the teams at the end of the race.

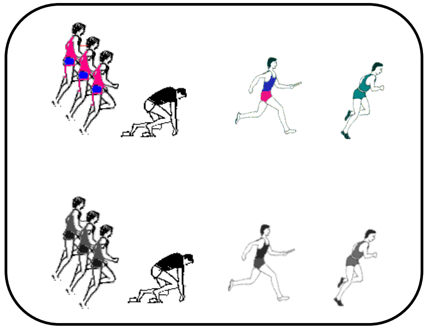
EXTERNAL SERVICES



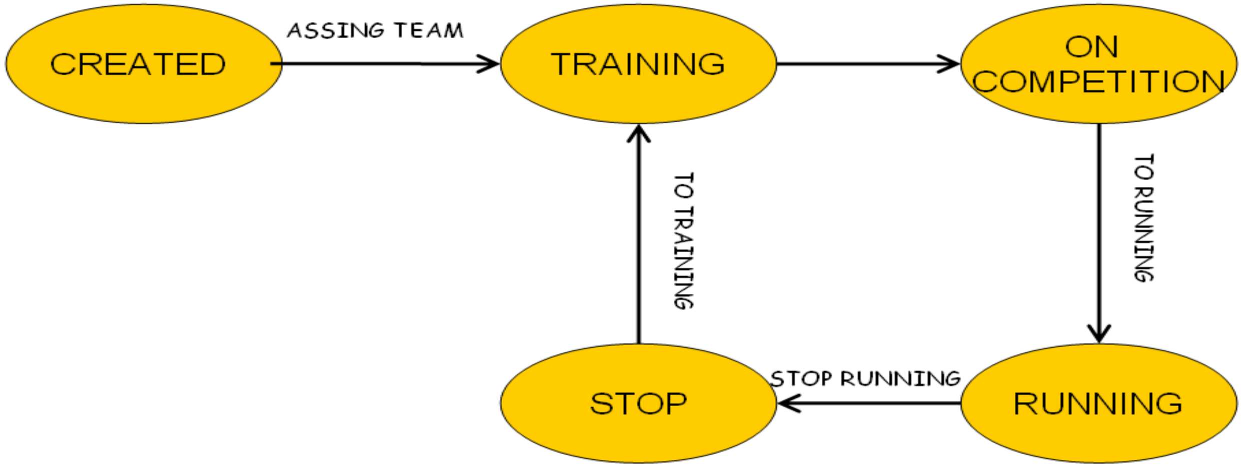
Relay Race

- **We use Java JSP and Java Servlet in order to implement external services useful for our application.**
- **Siena manages the race, controls the competition and sends to the JSP pages all the attributes required.**
- **The external services are:**
  - **RaceService**:
    >http://localhost:8080/Race/Race creates the Race.
  - **ShowRace**:
    >http://localhost:8080/OpenURL/Open opens a window that shows the race.
  - **Winner**:
    >opens a window with all the informations about the winner.

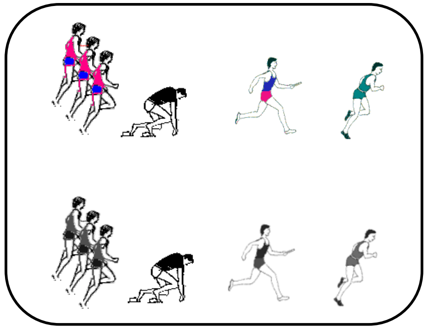
State Diagram: PLAYER



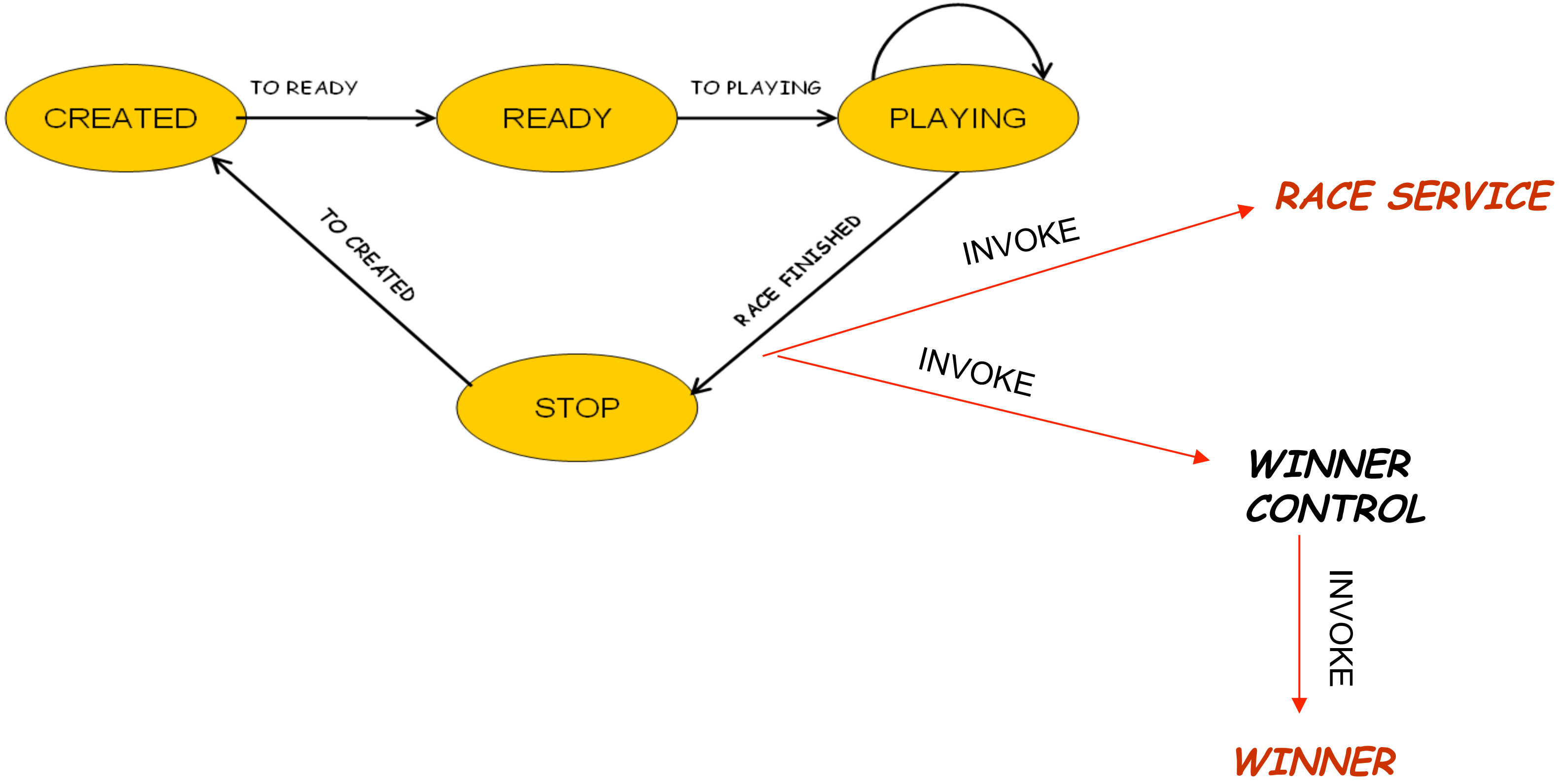
Relay Race



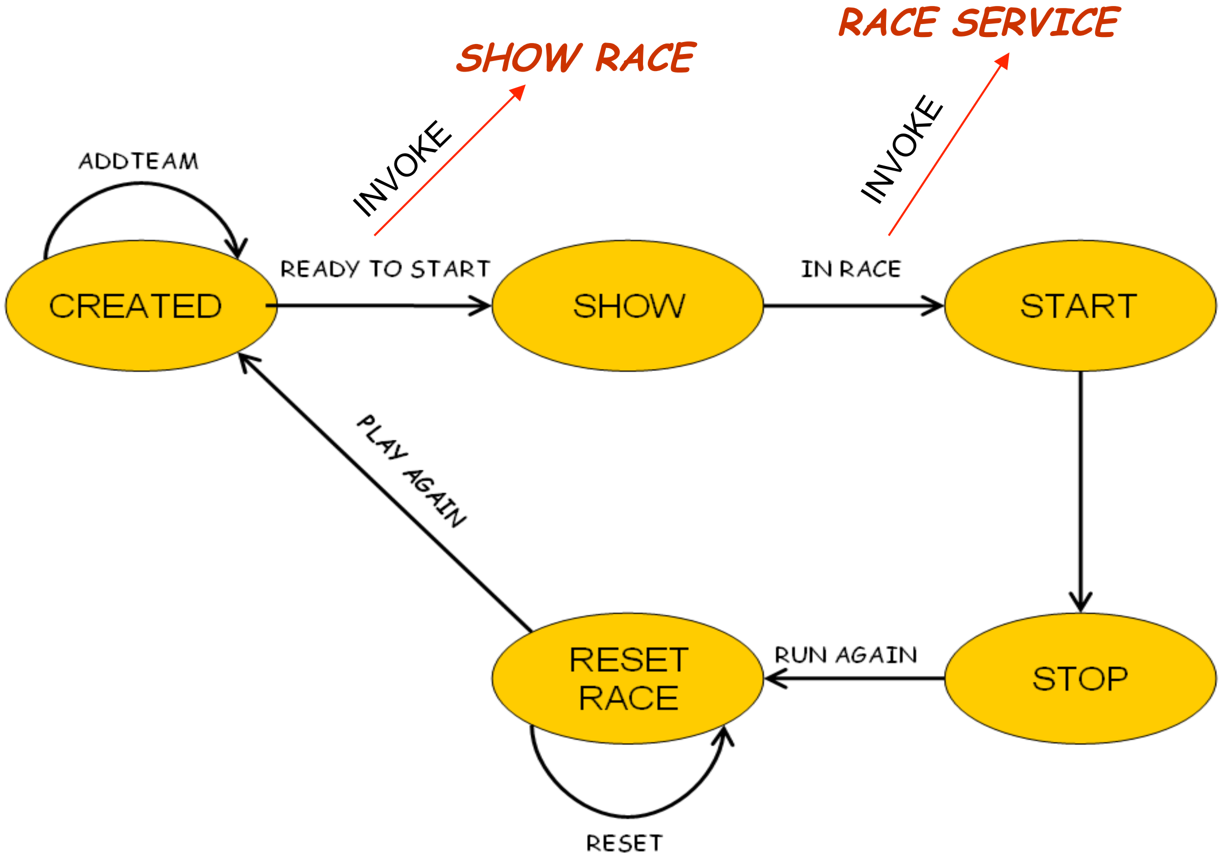
State Diagram: TEAM

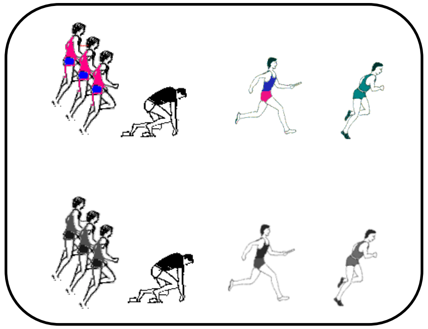


Relay Race



State Diagram: RACE





Relay Race