Determining Service Dependencies in Distributed Systems

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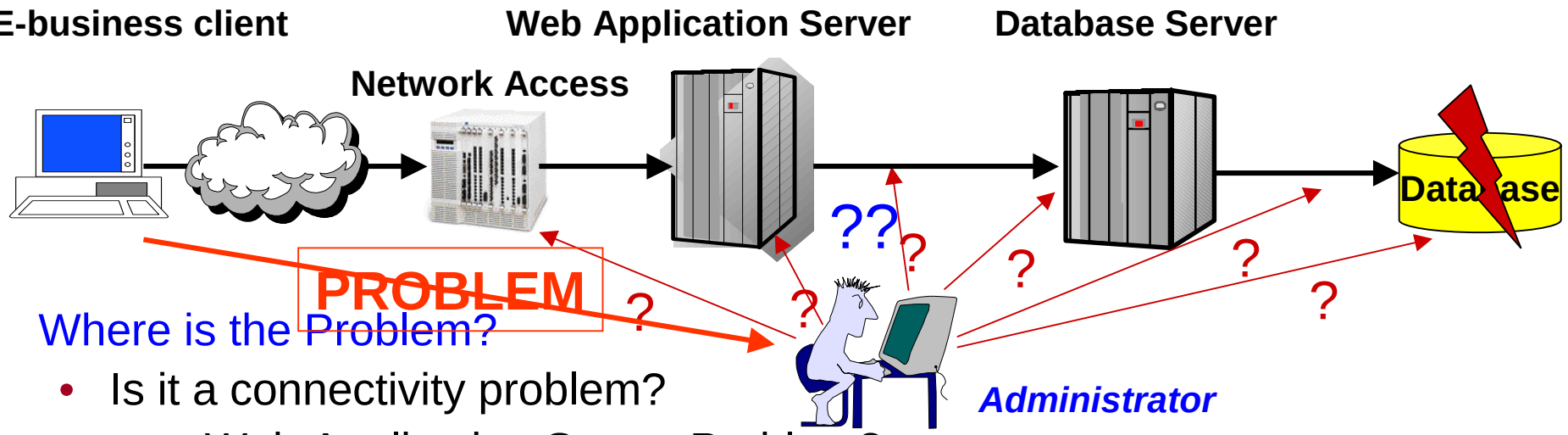
Motivation: Managing a Web Storefront

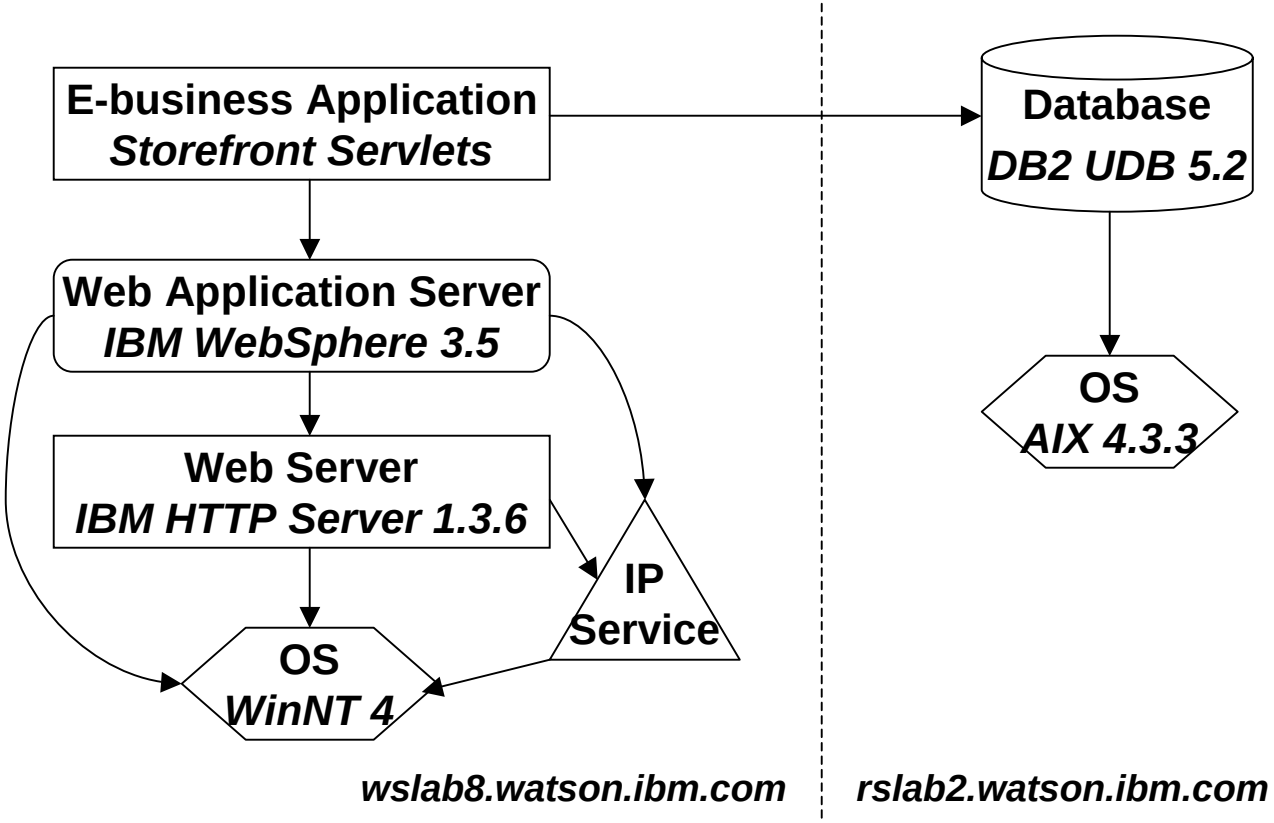


- Where is the Problem?
  - Is it a connectivity problem?
  - … a Web Application Server Problem?
  - … a Database Server Problem?
  - … an internal Database Error?
  - How are the different Components related?
- Mapping "Service ▹ Implementation (Product) ▹ Running Instance" essential:
  - obtaining the three Parts individually is tractable
  - combining the three Parts into a uniform Model is challenging
  - finding an efficiently computable Dependency Model is hard

Dependencies: Management Issues & Requirements

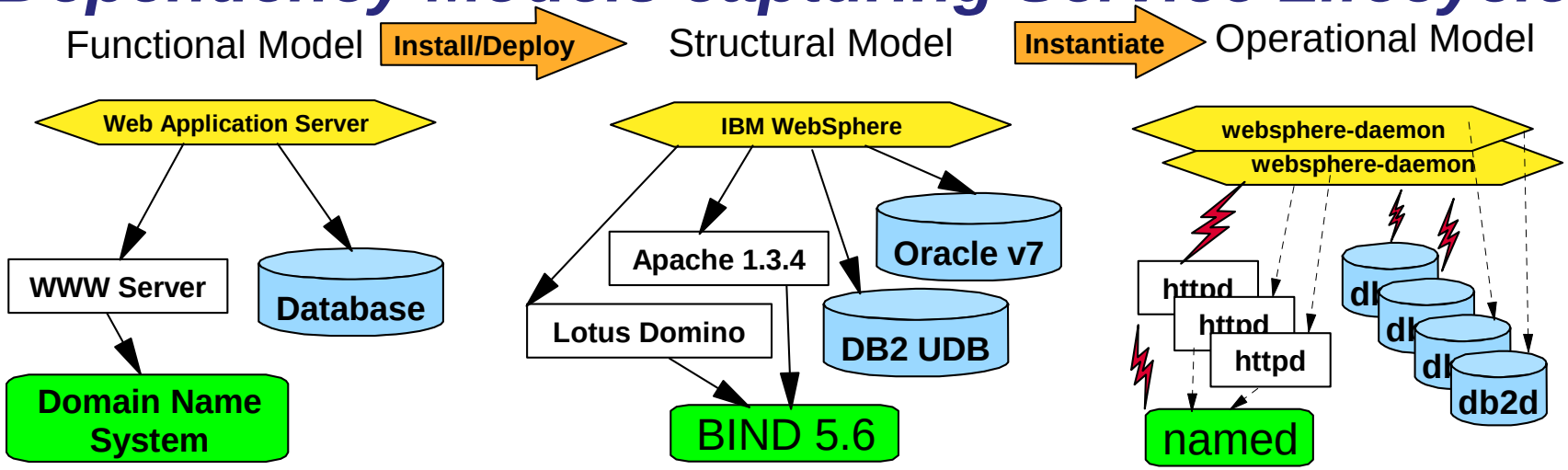
- Root Cause Analysis
  - Determine and isolate the Source of a faulty Service
  - **Today:** manual Test of Services by Operator, Service Dependencies not explicitly specified
  - **Needed:** “drill-down”, (automated) traversal of Layers to find Root Cause
- Impact Analysis
  - Determine which Services/Customers are affected by a Problem
  - **Today:** Planned Outages: Proactive Warnings, Accidental Outages: N/A
  - **Needed:** “drill-up”, determine potentially affected Services/Customers
- Requirements
  - Make Service Dependencies explicit, available & efficiently computable
  - Define an open Format for interchanging Dependency Information
  - Dependency Model must allow (recursive) Queries

Dependency Graph of a Web Storefront



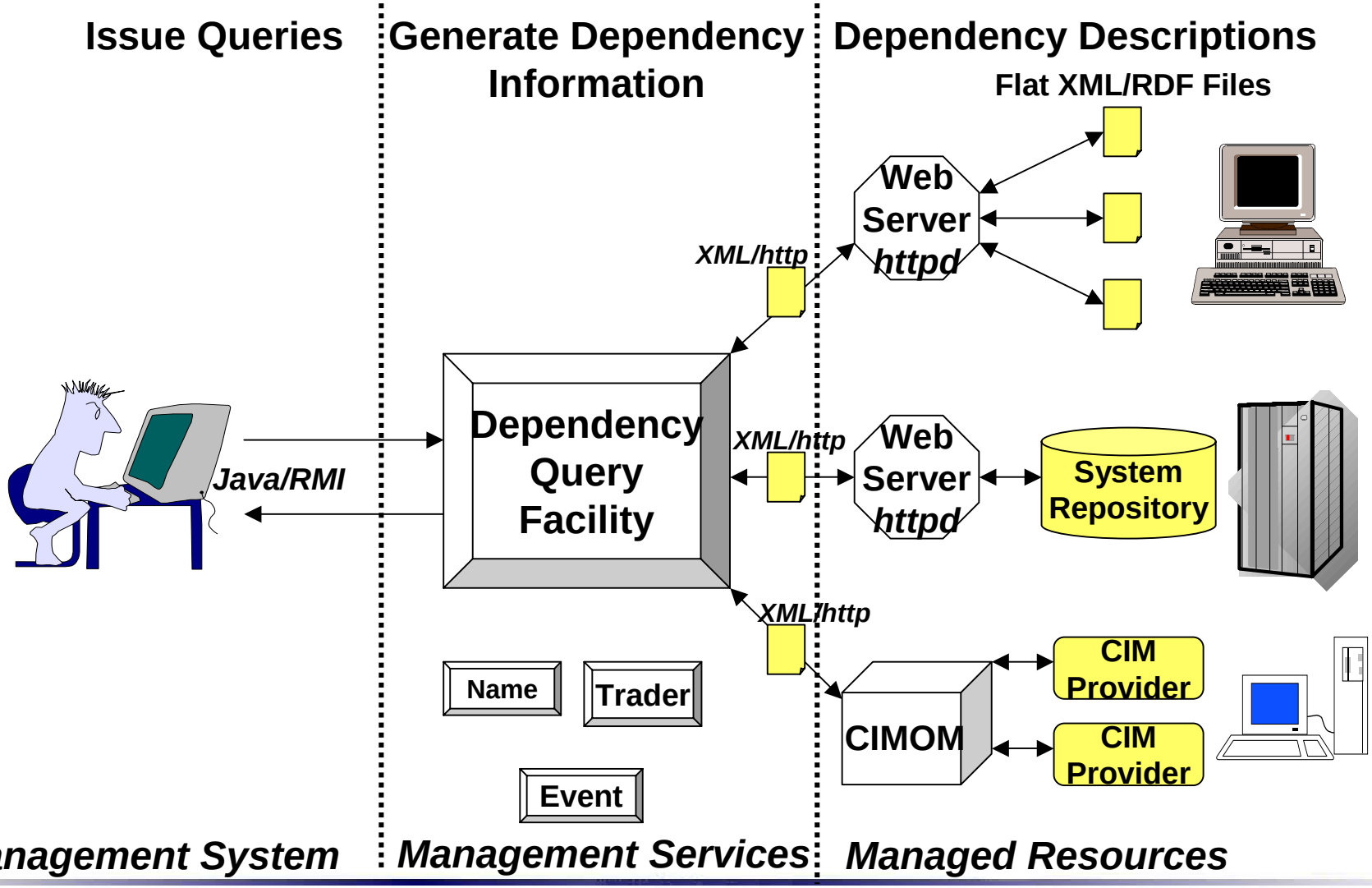
- Dependencies usually span multiple Systems and Domains (SLAs)
- Representation of Dependencies as directed, acyclic Graph
- Nodes represent Services, Edges represent Dependencies

Dependency Models capturing Service Lifecycle



- Functional Model
  - **defines dependencies between generic services (not: within)**
  - **further models are based on functional model and refine it**
- Structural Model (Manageability)
  - **detailed description of SW components based on system inventory**
  - **typically captured during installation/deployment**
- Operational Model
  - **created when bindings between services are established**
  - **highly dynamic - not stored but computed stepwise as needed**

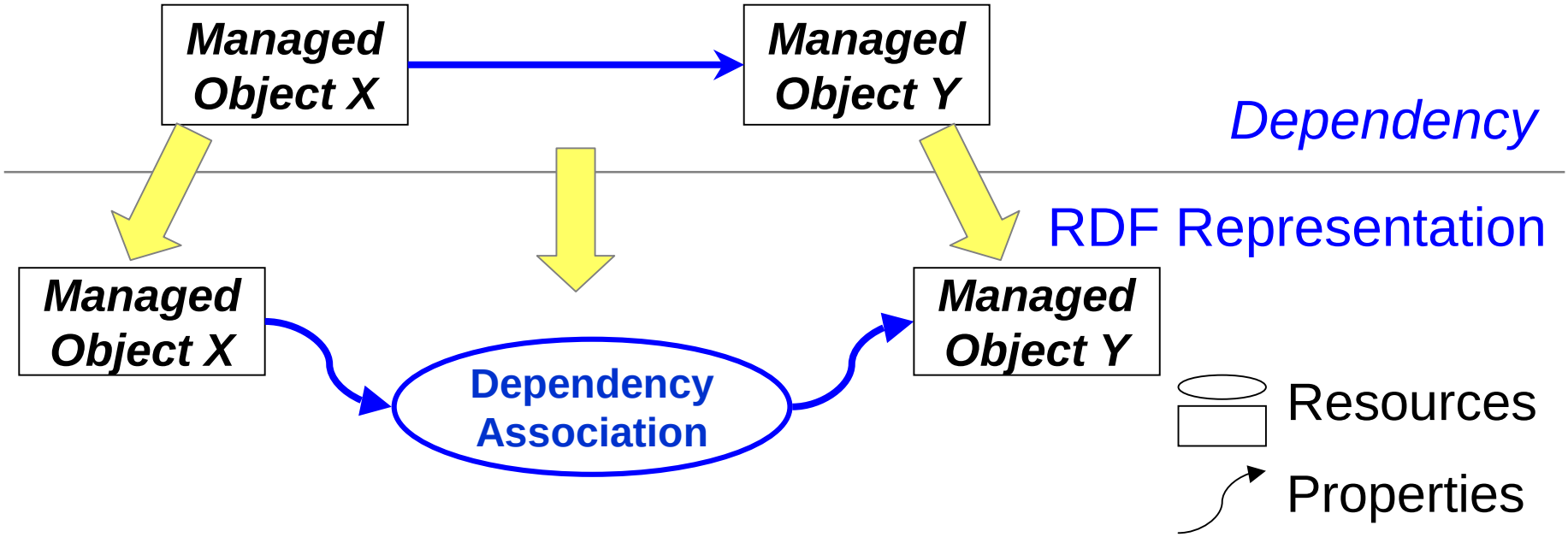
Distributed Dependency Processing: Architecture



Why use the Resource Description Framework?

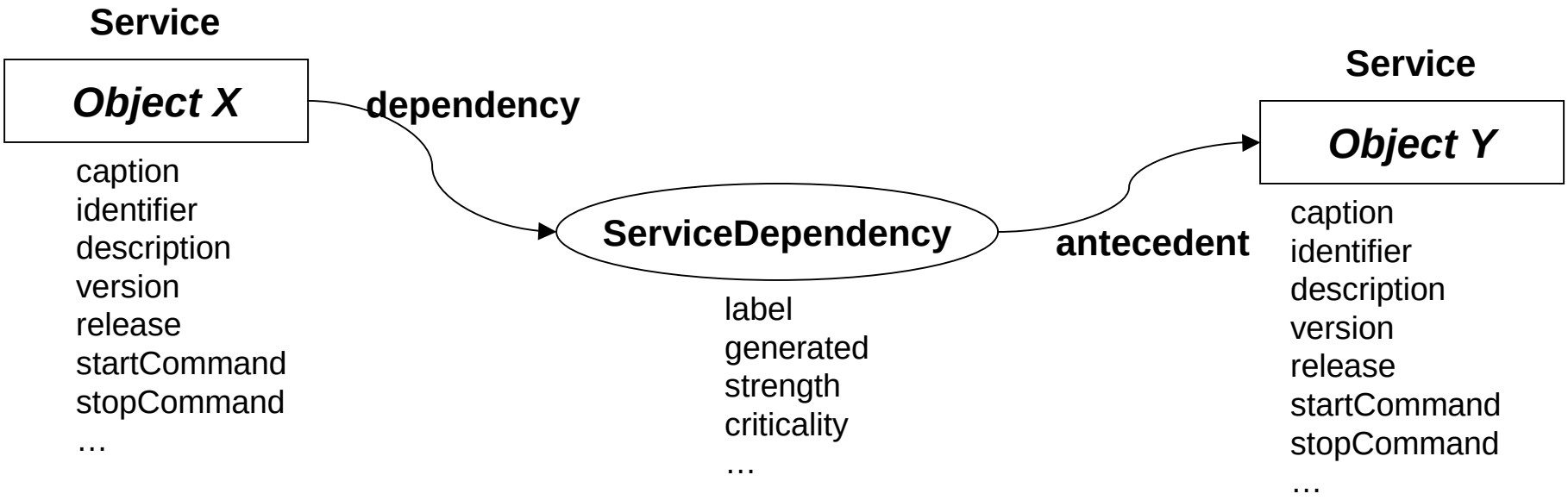
- Open Standard (W3C Candidate Recommendation)
  - Defines Metadata for XML Tags
  - Initially conceived for content classification of Documents
  - RDF Documents are XML Documents
    - can be parsed with off-the-shelf XML Parsers
    - can be queried with XML Path Language (XPath)
  - Type system: Distinction between MOs and Dependency Objects
- Applicability to our Work:
  - RDF is able to represent DAGs in (different) XML Documents
  - Nodes in a DAG can have attributes and reference other nodes
  - Dependencies can be qualified with attributes for classification
    - E.g., “start”, “stop”, “failover”, “strength”, “criticality”, “generated” etc.
    - Allows searching for MOCs, dependency types and their properties

Expressing Dependencies in RDF



- Straightforward 1:1 Mapping for Managed Objects
- Dependency Association is an Object on its own (can have Attributes)
- Managed Objects and Associations are *RDF Resources*
- Links between MOs and Association are *RDF Properties* of the resp. Objects

Elements of a Dependency Description

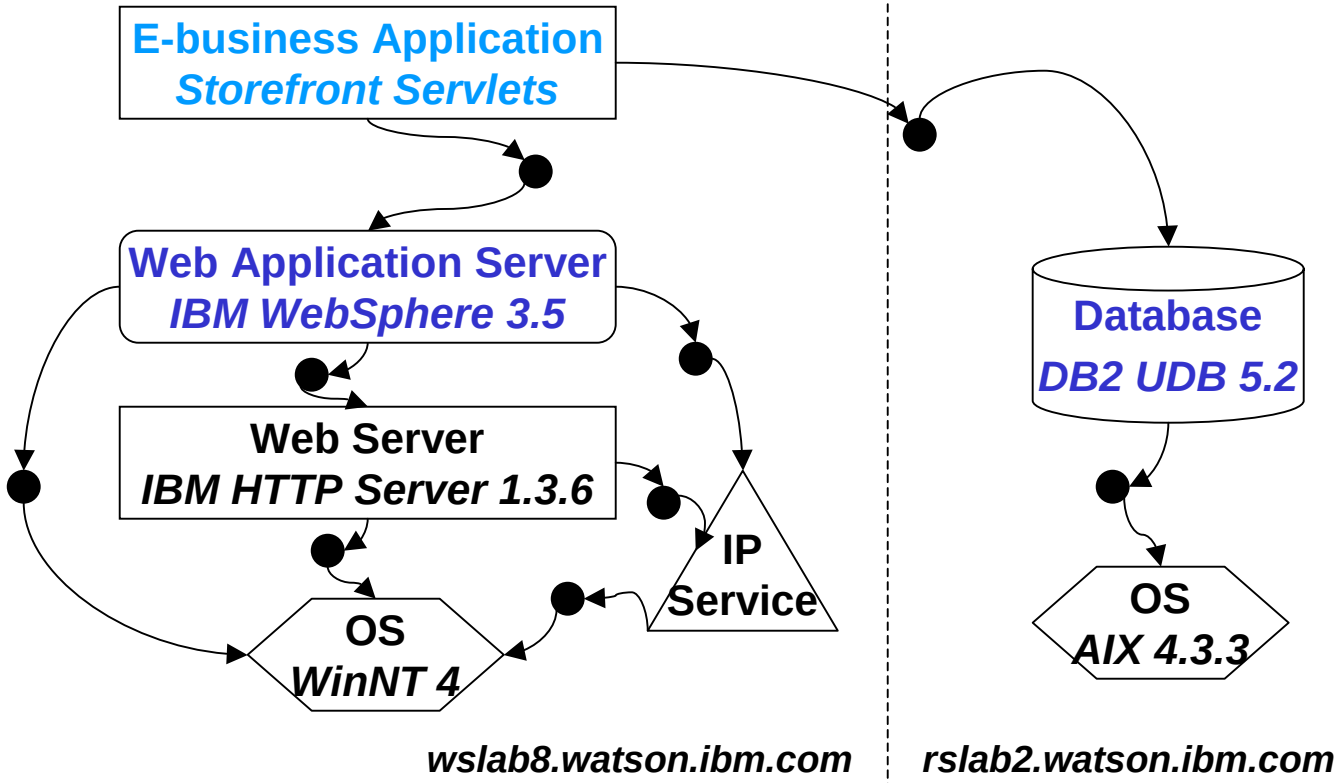


- Service: Managed Object with various Attributes
- dependency: RDF property of Service
- ServiceDependency: Attributes help classify Dependency
- antecedent: RDF property of ServiceDependency
- Dependencies modeled as unidirectional Links

Querying Dependency Graphs with XPath

- Open Standard (W3C Recommendation)
- Combine various XML Documents into a new Document
- Compact, reusable Query Expressions
- Used here for:
  - Navigating Dependency Graph and selecting Nodes
  - Applying filtering Rules to the Nodes
  - Building an XML Document containing the Results
  - cf. OSI “Scoping and Filtering”
- Dependency Graphs can be navigated in both Directions
  - From top to bottom: finding Root Cause
  - From bottom to top: performing Impact Analysis
  - Either step-by-step or recursively (“Drill-down”, “Drill-up”)

Applying XPath: Antecedents of E-business Application




```
/descendant::[(self::ds:Service)]/child::ds:dependency/
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➨ Yields the URIs of `Web Application Server` and `Database`

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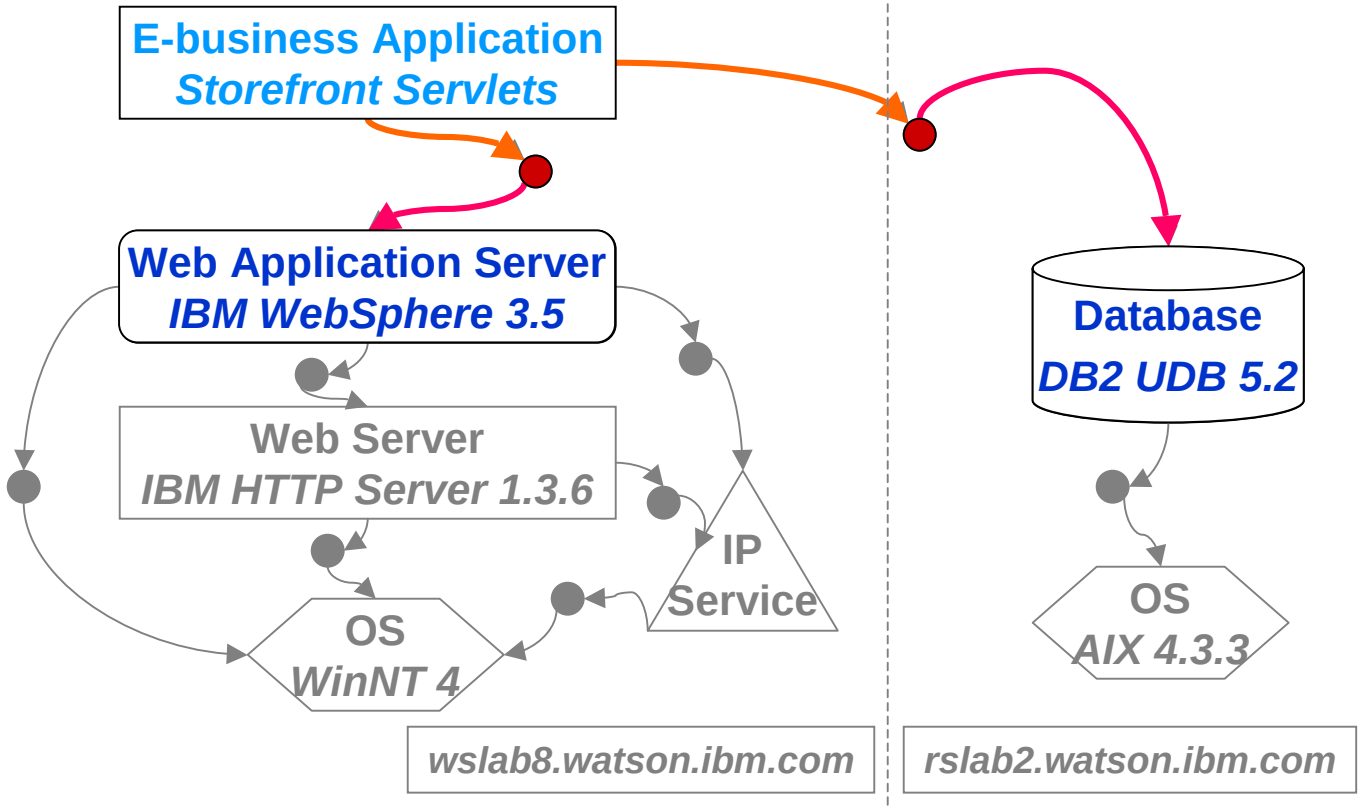


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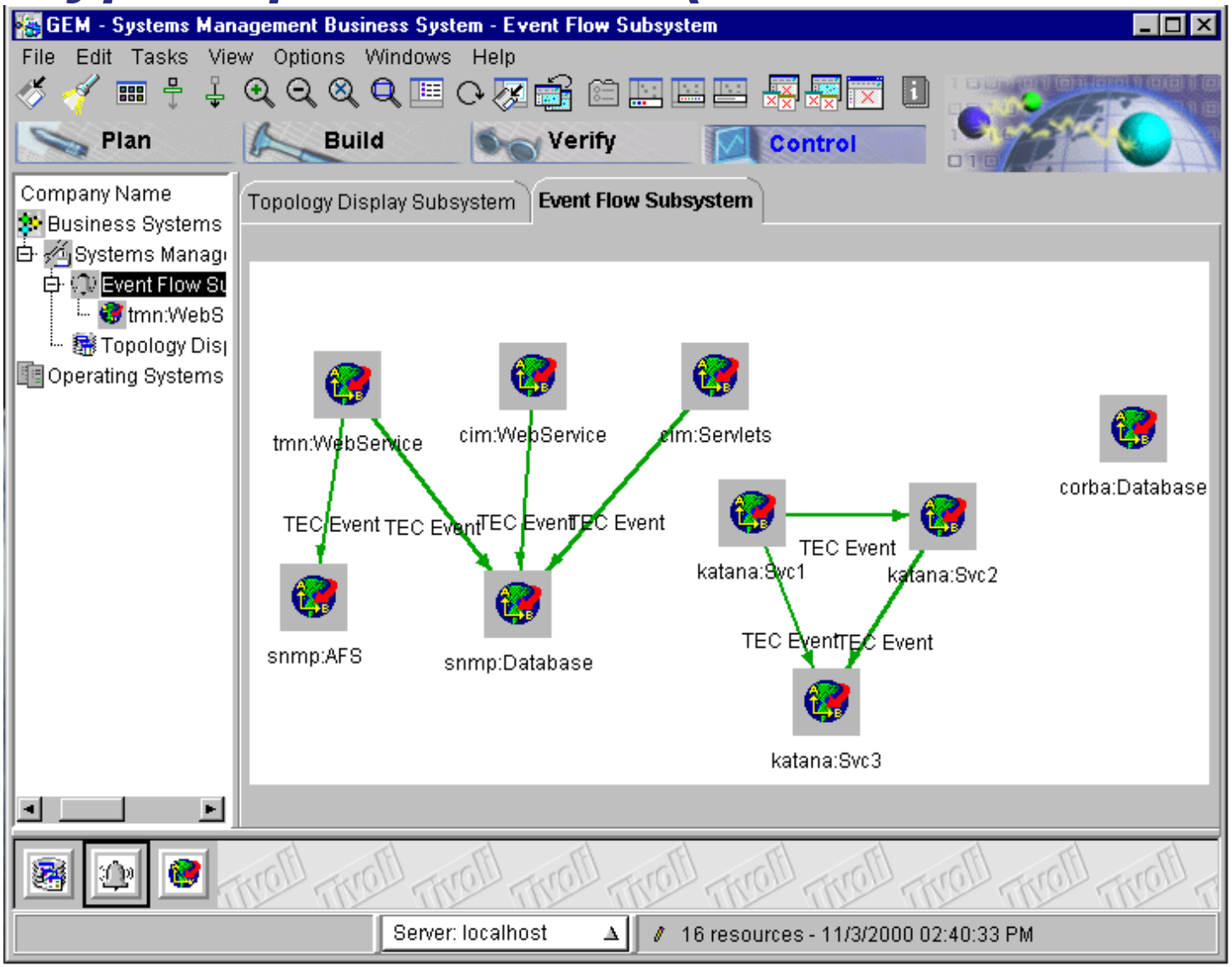
Prototype Implementation (based on Tivoli GEM)



Conclusions and Outlook

- Results:
  - RDF for representing DAGs in XML, hierarchical Type System
  - Exploit inherent Strengths of widespread Representation Format
  - Minimum overhead by delegating the bulk of work to XML tools
  - XPath as a straightforward means to:
    - Navigate Dependency Data
    - Issue (recursive) Queries against multiple distributed XML Documents
    - Combine Results into one XML Document
- Current work:
  - Distinguishing between Instances of hosted Applications requires further Instrumentation
  - Optimizing memory consumption by SAX or efficient DOM Parsers
  - Integration with available CIM Object Manager
  - Propose Extensions to CIM RunTime Application Working Group