

Applications of ICT Standards in Engineering

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Gaithersburg, MD 20899

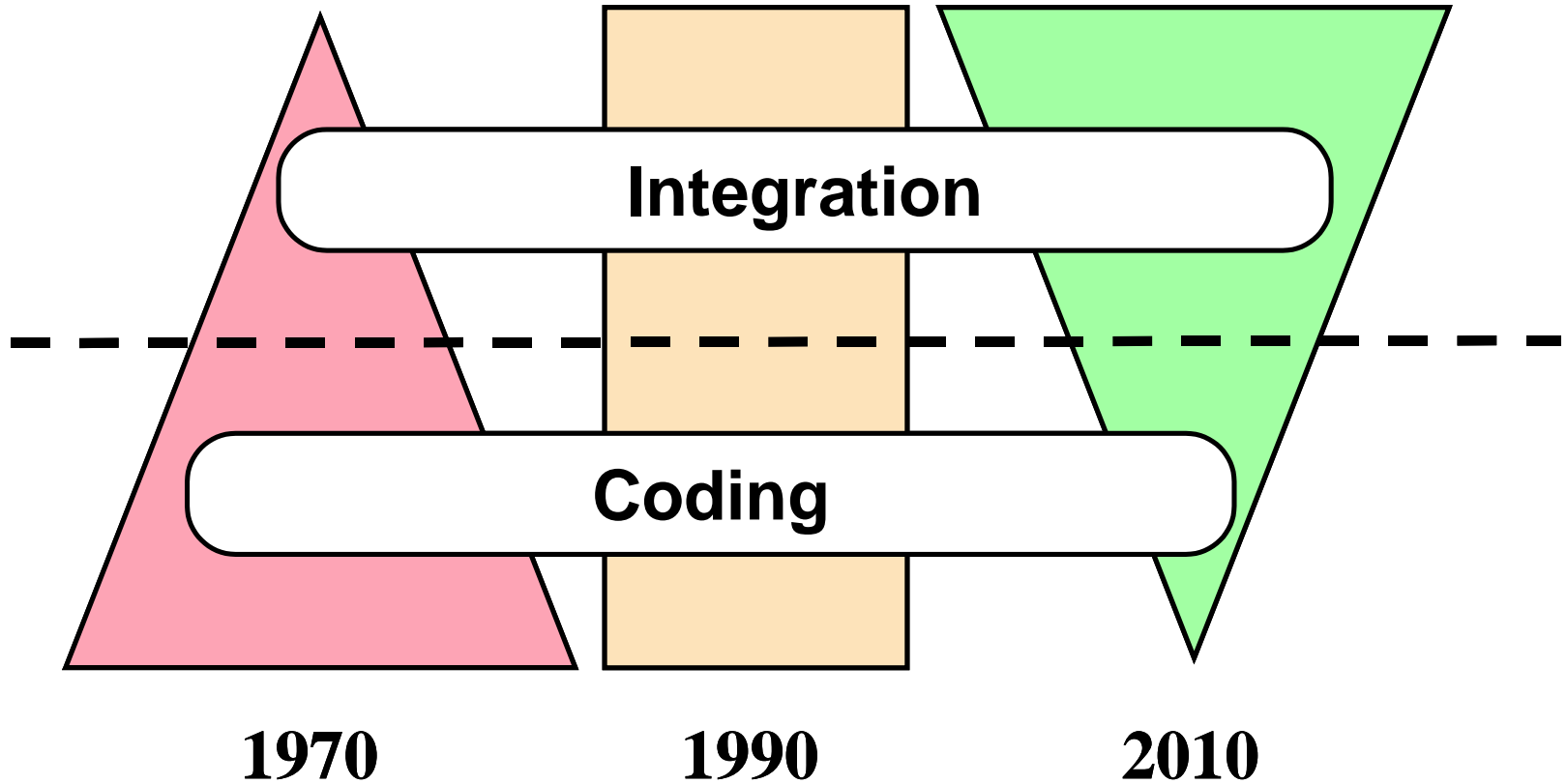


Scope and Outline

- Engineering industrial interoperability standards
 - Product data exchange
 - Process information exchange
- Expanding application functionalities through interoperability
 - Integrating Product Data and Process Information
 - Engineering Web-based Services
- Brief discussion on further interoperability needs



Paradigm Shift in Software Development

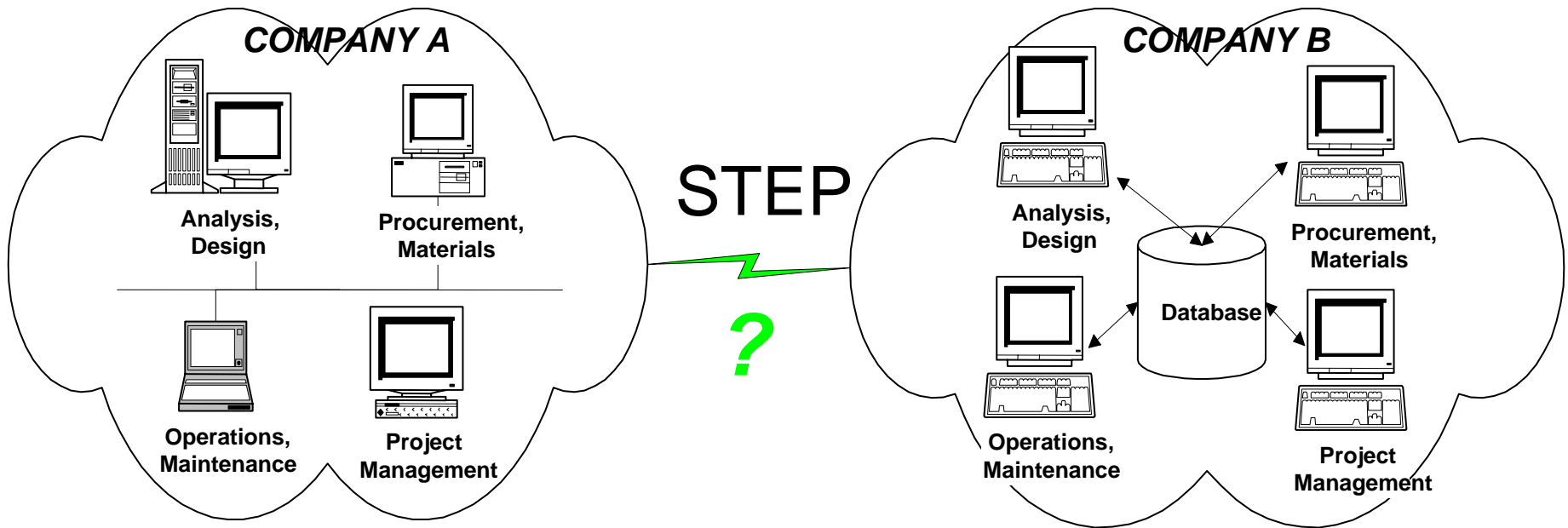


Information AND Communication Technology (ICT) to provide:
Universal Access, Integration, Coordination of Engineering Services

Data Exchange

A Mechanism for Software Interoperability and Communication within and between Companies

STEP: STandards for the Exchange of Product Data



STEP Application Protocols

Part 201 Explicit Drafting

Part 202 Associative Drafting

Part 203 Configuration Controlled Design

Part 204 Mechanical Design Using Boundary Representation

Part 205 Mechanical Design Using Surface Representation

Part 206 Mechanical Design Using Wireframe Representation

Part 207 Sheet Metal Dies and Blocks

Part 208

Part 209

Part 210

Part 211

Part 212

Part 213

Part 214

Part 215

Part 216

Part 217

Part 218

Part 219

Part 220

Part 221

Part 222

Part 223

Part 224

Part 225

Part 221 Functional Data and Schematic

Representation for Process Plans

Part 220 Printed Circuit Assembly Manufacturing Planning

Part 222 Design Engineering to Manufacturing for Composite Structures

Part 223 Exchange of Design and Manufacturing DPD for Composites

Part 224 Mechanical Product Definition for Process Planning

Part 225 Structural Building Elements Using Explicit

*Data Exchange Standards for
Various Engineering Applications
Do Exist*

Part 233 Systems Engineering Data Representation

Part 234 Ship Operational logs, records and messages

Part 235 Materials Information for products

Part 236 Furniture product and project

Part 237 Computational Fluid Dynamics

Part 238 Integrated CNC Machining

Part 239 Product Life Cycle Support

Processes

Part 215 Ship Arrangement

Part 216 Ship Molded Forms

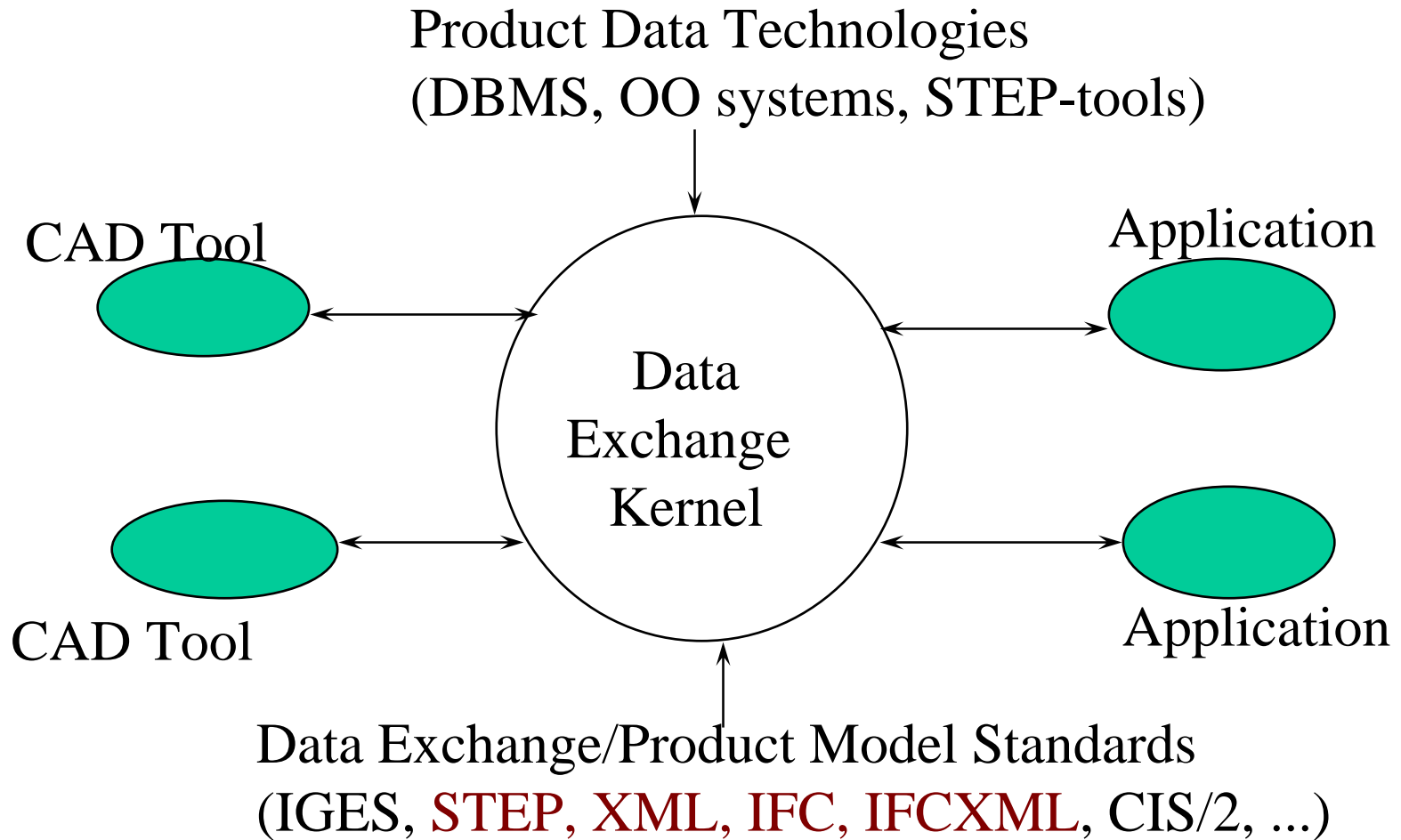
Part 217 Ship Piping

Part 218 Ship Structures

Part 219 Dimensional Inspection Process Planning for CMMs



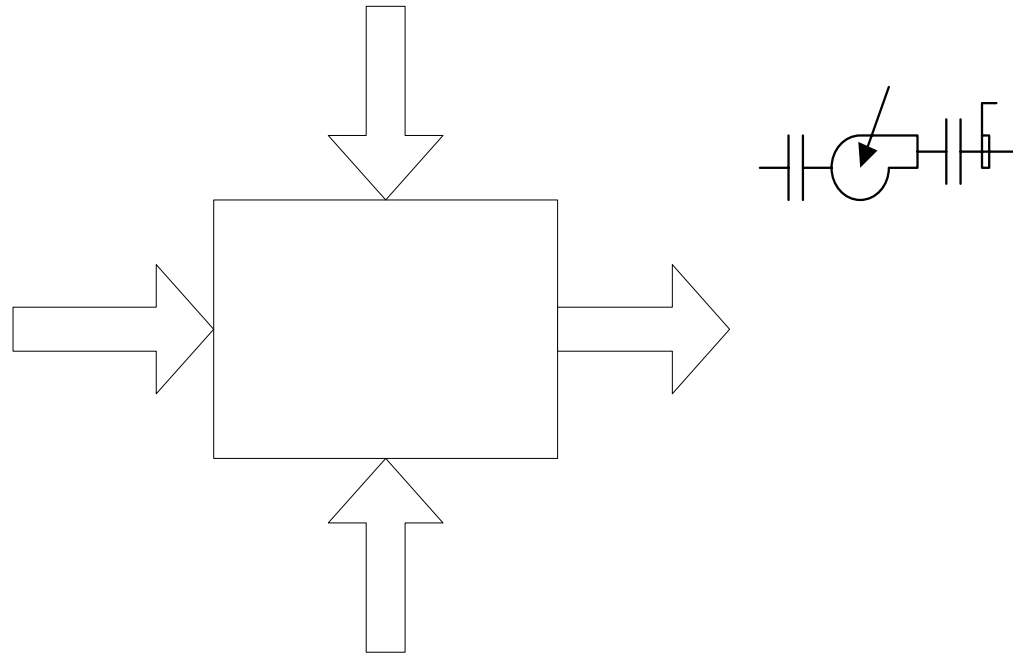
Data Exchange Standards



Domain specific standards provide product data level semantics

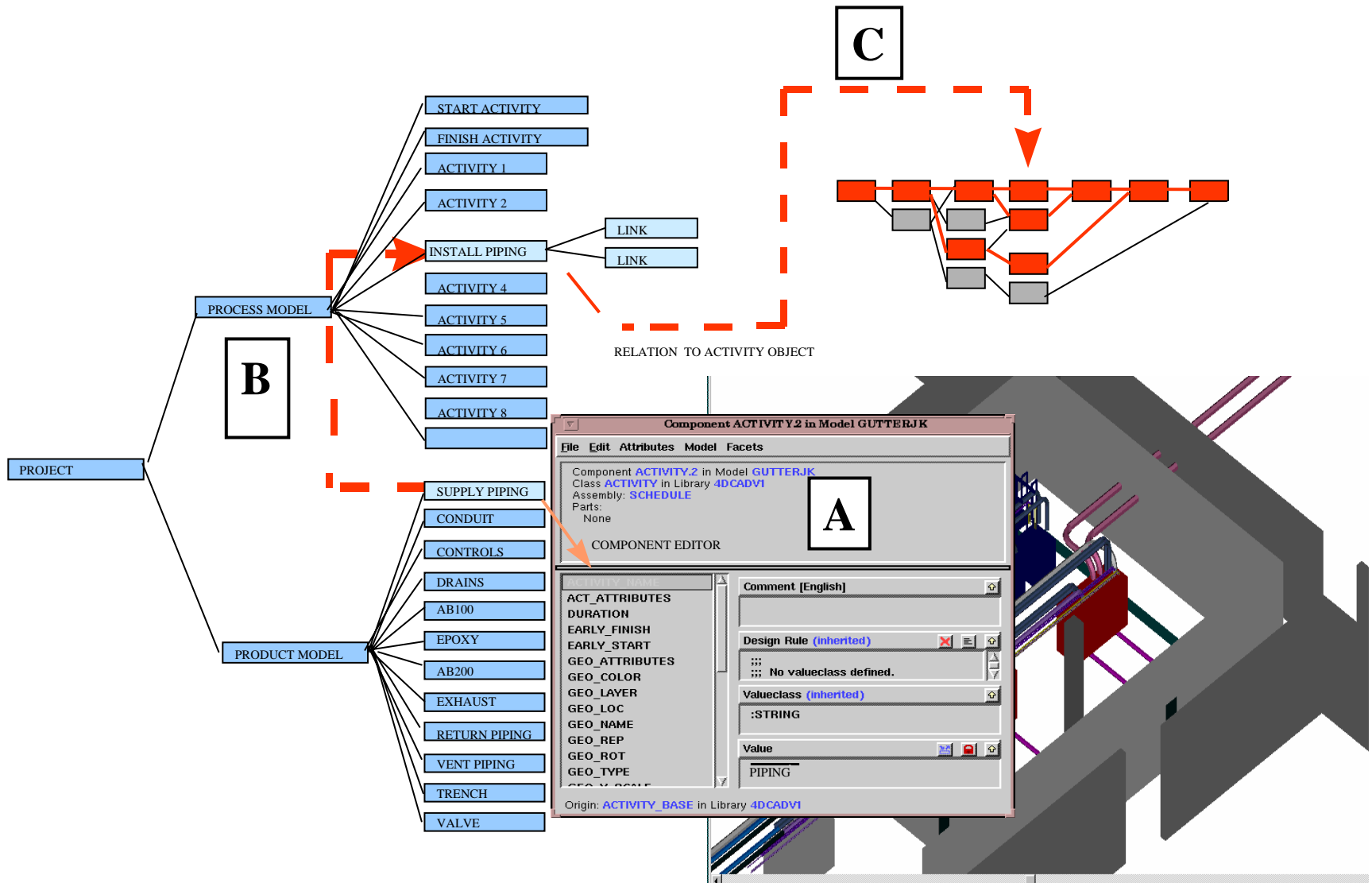


Product Model



Product Model: {form, function, behavior}

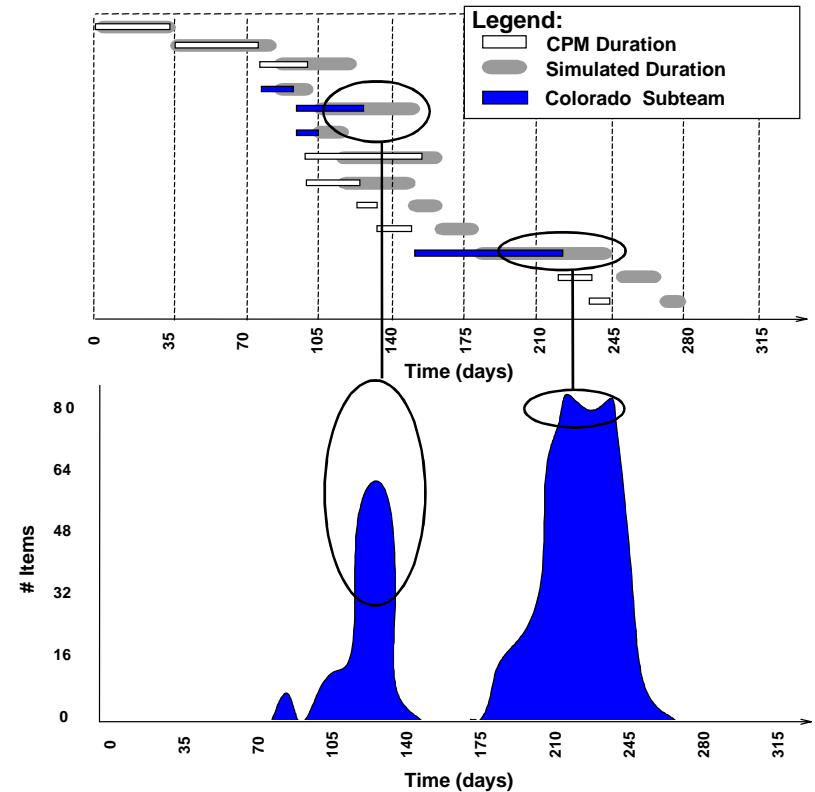
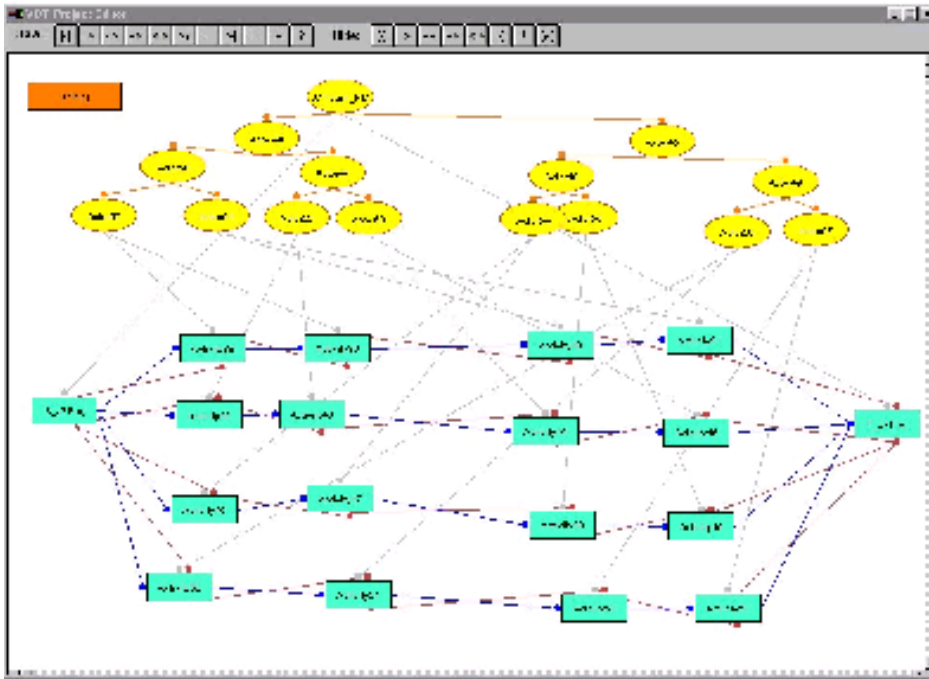
Product Modeling and Process Specification



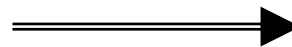
Process Model

Activities : {Tasks, Schedules, ...}

Resources: {Equipment, Organization, Labor, Skills, ...}



Resources + Activities



Performance

Process Information Model

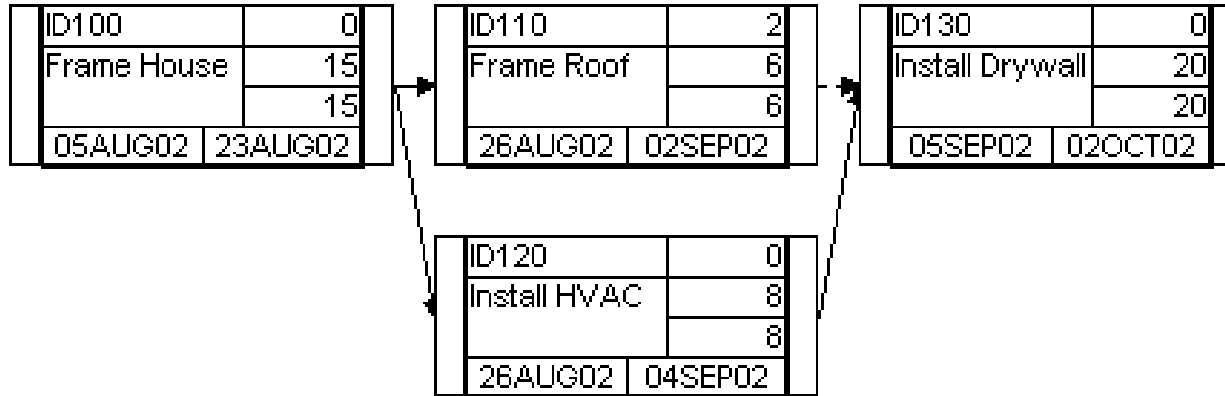
Process Specification Language (PSL)

PSL : Interchange Standard for Process Information

- Initiated by NIST
- Major components: **PSL-core**, **core theories**, and **extensions**
- PSL-core: based on a precise mathematical first-order theory (**Object, Activity, Activity Occurrence** and **Timepoint**)
- Syntax based on KIF (Knowledge Interchange Format) – **terms, axioms, relations, functions, .. (FOP useful for detecting conflicts)**
- Manufacturing Industry -> Other Industry (Construction)



Ontology Mapping between PSL and Application Concepts



Example Schedule in Primavera P3

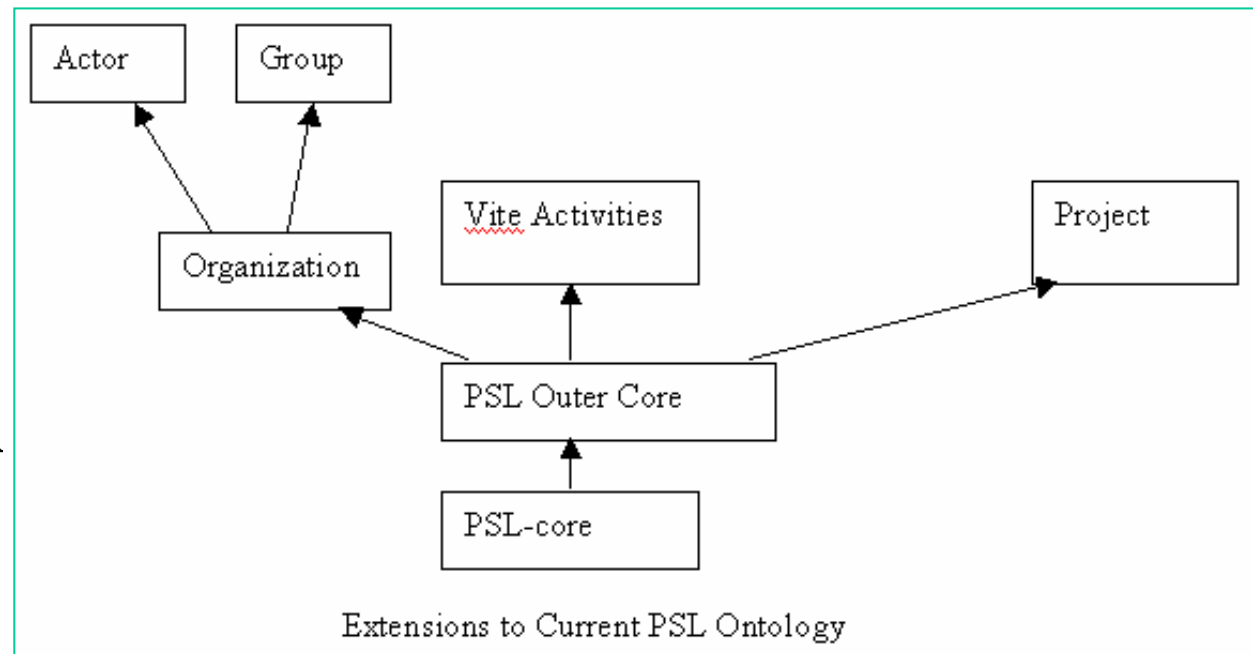
Concepts in Primavera P3	PSL terms
Activity	Activity occurrence
Predecessor, Successor	Activity occurrence, before-start, before-finish, after-start, after-finish
Start to Start	Before-start
Dependency Lag	before-start-delay, before-finish-delay, after-start-delay, after-finish-delay



Ontology Extension for Related Applications

Current PSL Ontology:

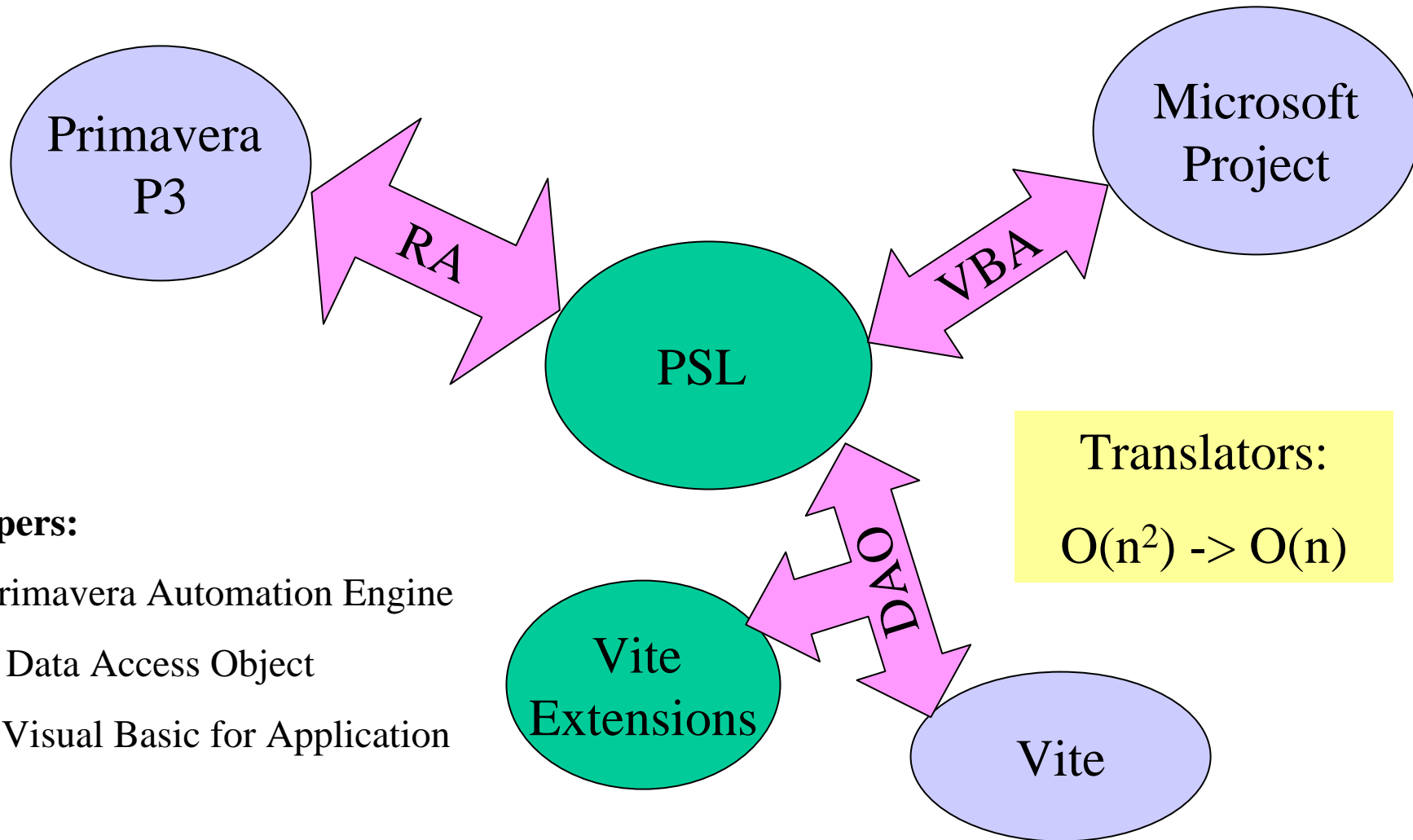
- **PSL Outer Core:** subactivity, activity occurrence, state
- **Examples of extensions:** Ordering relations, duration, nondeterministic activities, reasoning about state



**Extensions for
Vite (VDT) – a
Project Simulation
Tool on Resources
and Organization**



Process Information Exchange



Wrappers:

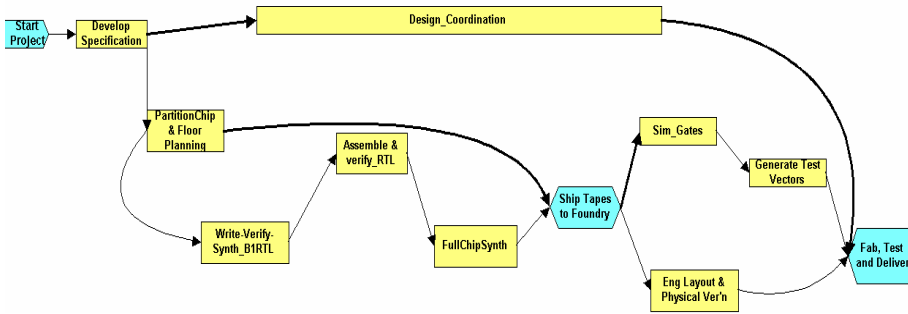
RA: Primavera Automation Engine

DAO: Data Access Object

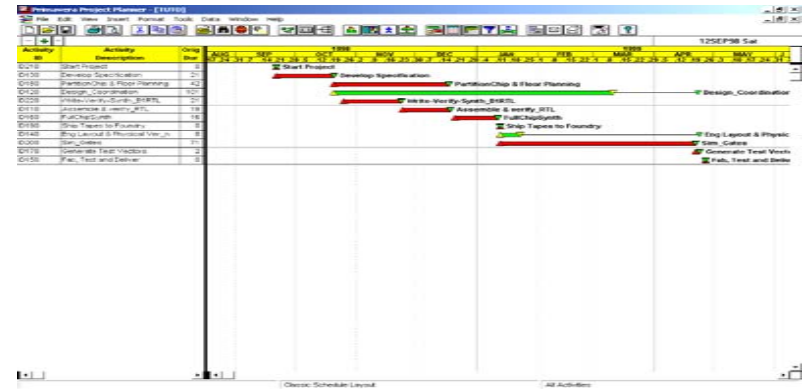
VBA: Visual Basic for Application



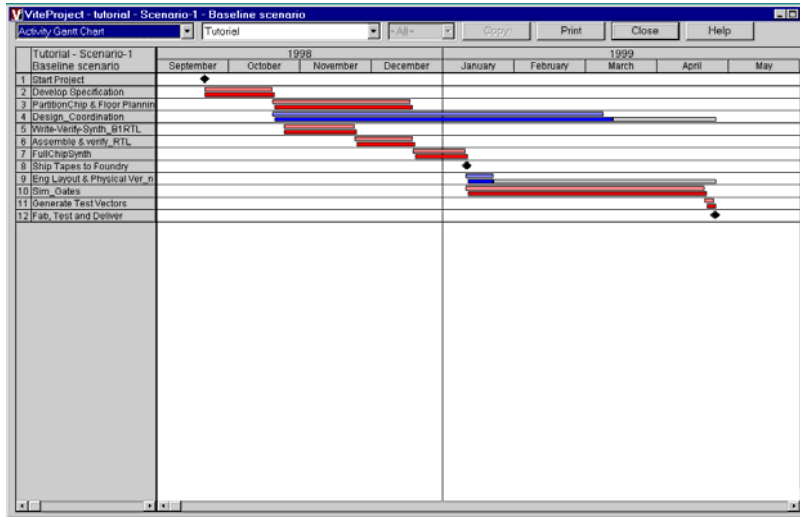
Information Exchange among Applications



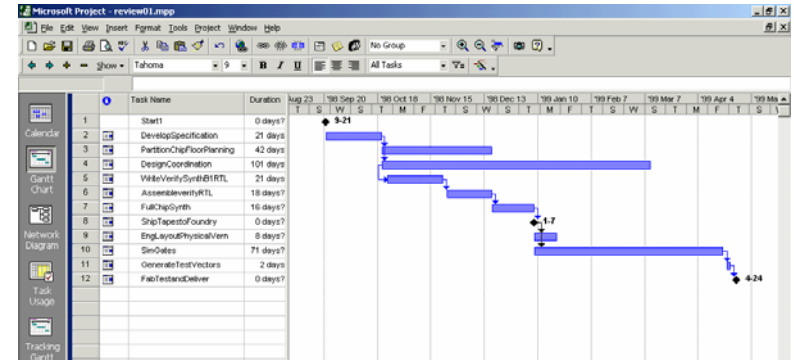
CPM Diagram In Vite



Gantt Chart In Primavera P3



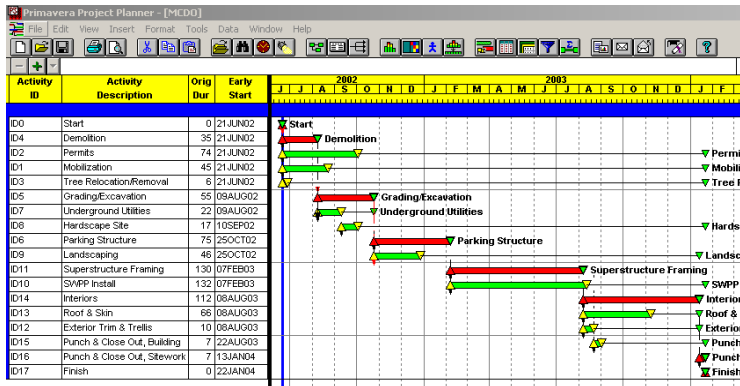
Gantt Chart In Vite



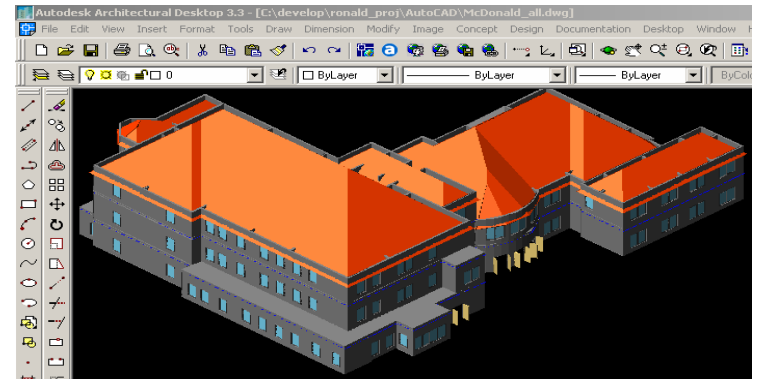
Gantt Chart In Microsoft Project



Product + Process Models: Integrating CAD and Scheduling



Project Schedule in P3



3D Model in Architectural Desktop

SimAL 3D View Service - Microsoft Internet Explorer

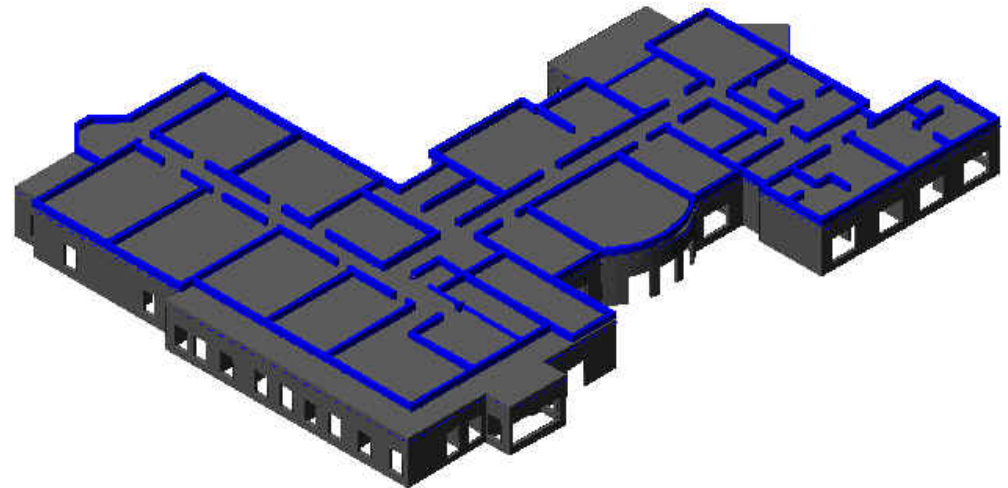
Address: <http://psl.stanford.edu:8080/CAD/servlet/CADService>

SimAL 3D View Service

Please enter the following information for the 3D View Service:

Select Project:

Set Target Date:



Many Proposed Standards for Web Services and Workflow

Examples:

SWSF (Semantic Web Services Framework): {language, ontology}

FLAWS (First-order Logic Ontology for Web Services)

ROWS (Rules Ontology for Web Services)

WSDL (Web Services Description Language)

BPEL4WS (Business Process Execution Language for Web Services)

UDDI (Universal Description, Discovery and Integration)

OWL-S (OWL ontology for web services)

PSL (process specification language)

WSML (Web Services Modeling Ontology) (WSML – OWL, WSML)

BPSS (ebXML's Business Process Specification Schema)

WSFL (Web Services Flow Language)

Wf-XML, XPDL, XLANG



MegaService: Composition and Coordination of On-Line Engineering Services

- Service Composition and Integration

(Scalability and Performance):

- Distributed Data Flow and Centralized Control Flow
- Active Mediation and Mobile Class (Objects)
 - device independent applications

- Service Specification and Execution

(Ease of composition):

- Simulation Access Language

- Data Interoperability:

XML-based (for product data), PSL (for process data)



MegaService: Composition of Online Services

Service Specification + Data Communication

- Software Program :
Execution Sequence + Data/Messages
- Workflow/Process Management:
Activities/Work-items + Information Flow
- **Service composition:**
Control Flow + Data Flow

Engineering Services deal with Large Data Sets!

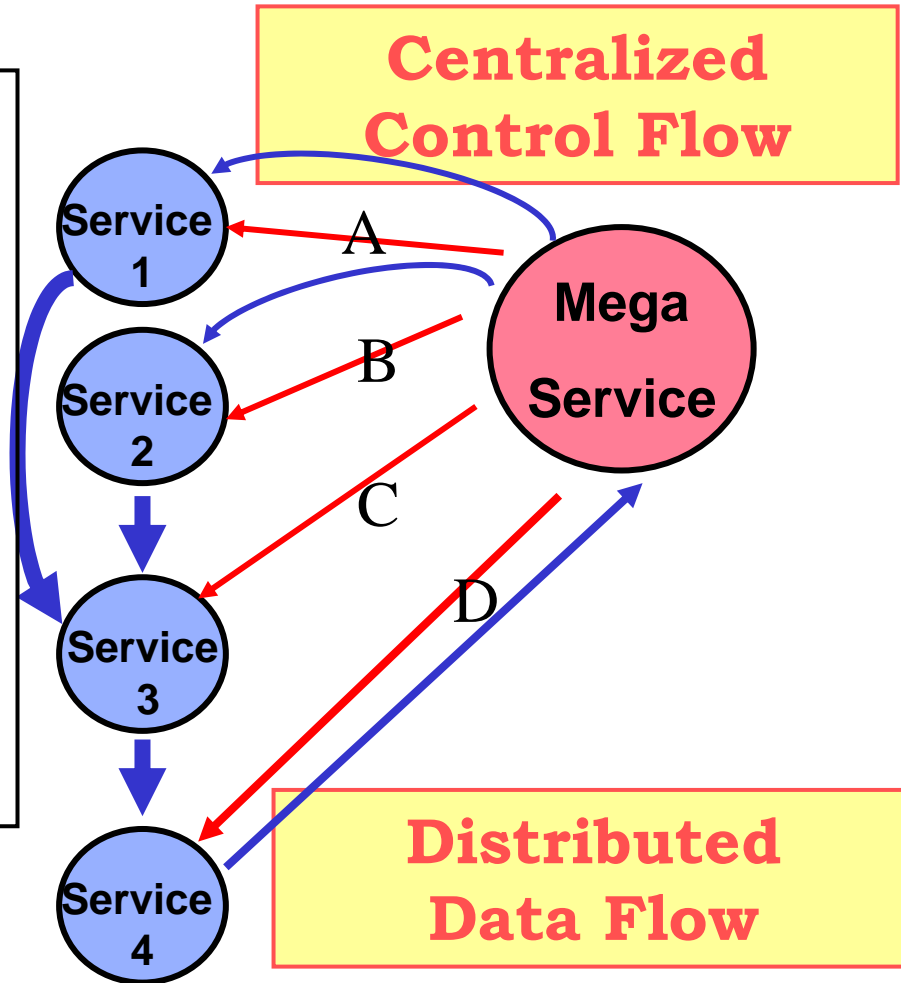


Event Dependency Graph:

FICAS Model - Distinct Control and Data Flows

```
,QYRFDWLRQ 6HUYLEFH ,192.(  
,QYRFDWLRQ 6HUYLEFH ,192.(  
$ ,QYRFDWLRQ (;75$&7  
% ,QYRFDWLRQ (;75$&7  
  
,QYRFDWLRQ 6HUYLEFH ,192.( $ %  
& ,QYRFDWLRQ (;75$&7  
  
,QYRFDWLRQ 6HUYLEFH ,192.( &  
' ,QYRFDWLRQ (;75$&7
```

Execution Sequence
of a MegaService



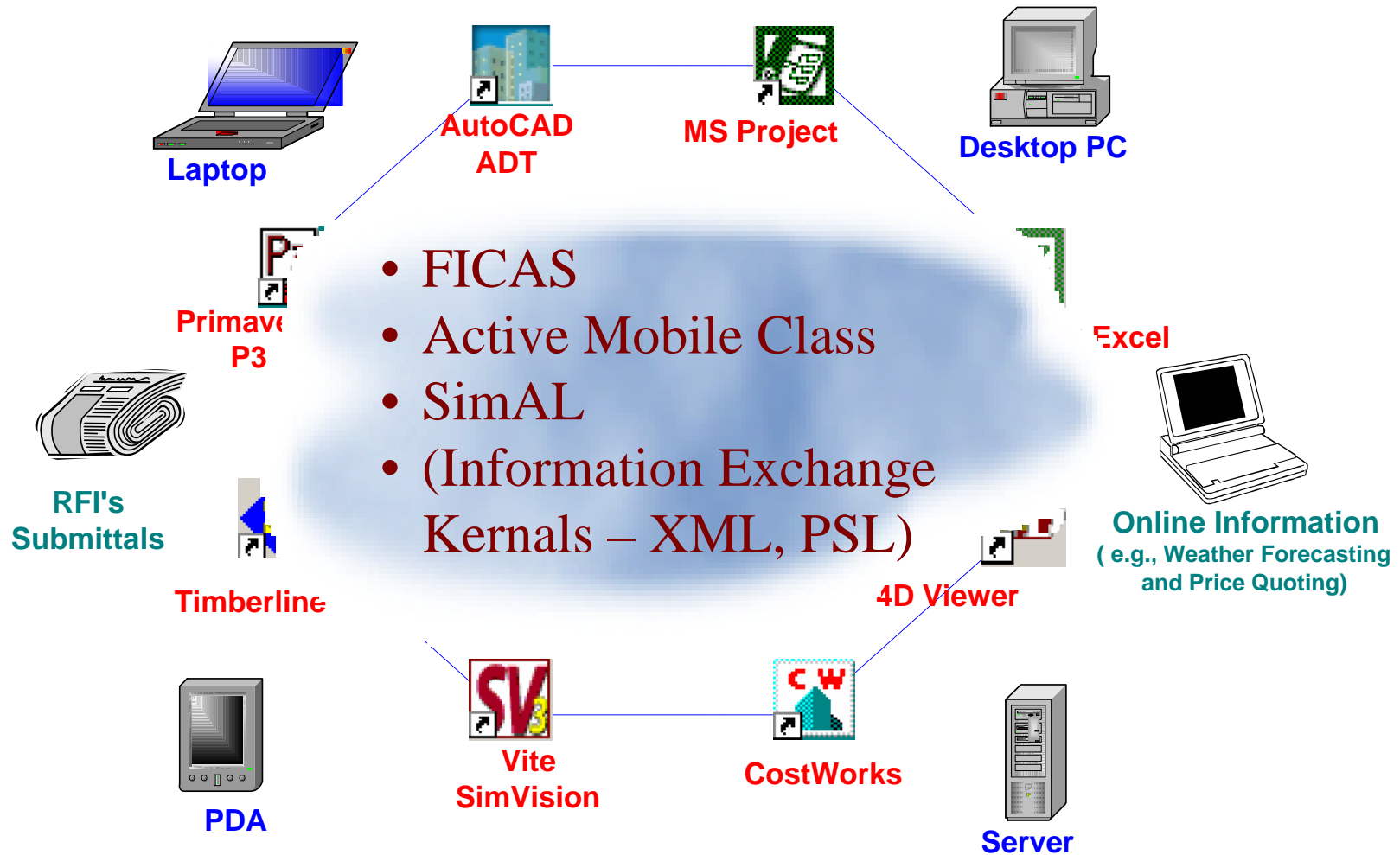
Service Specification:

Simulation Access Language

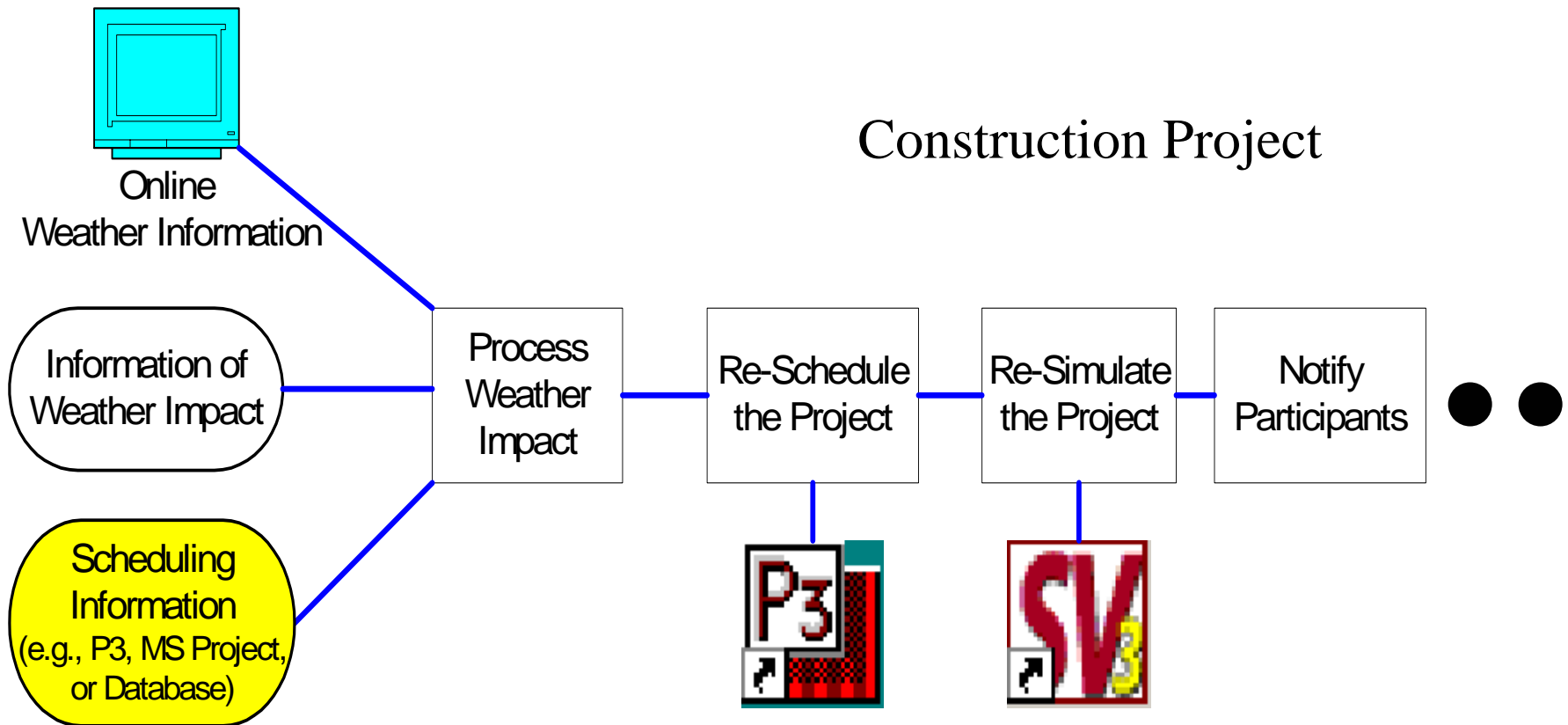
- **A Simple Easy-to-Use High-Level Language**
 - Coordinating Services and Managing Information Flow
 - Simulating and Comparing Scenarios
- **Major Components**
 - Invocation Statements (**SETUP, INVOKE**)
 - Operation Statements (**QUERY, UPDATE**)
 - **SELECT**, to query information from the simulation results
 - **SET**, to update project models in simulation tools
 - **DELETE**, to delete objects in project models
 - **INSERT**, to insert objects in project models
 - Control Statements (**IF-THEN-ELSE, WHILE**)
 - Decision-support Statements (**SCENARIO CREATION, SCENARIO COMPARISION, etc.**)



MegaService Simulation Utilizing (Wrapped) Web-based Services



Scenario: *Incorporating Online Information into Workflow*



Embedding SimAL Program Segment in Excel

The screenshot shows a Microsoft Excel window titled "Microsoft Excel - SimAL_1.xls". The worksheet contains a form for project information and a SimAL program segment. The form fields are:

	C	D	E	F
1	Project Name	MCDO		
2	Location	West Palm Beach, FL		
3	Zip Code	33410		
4	Services	Primavera P3		
5		Microsoft Project		
6		Vite SimVision		
7		Weather Service		
8	Simulate Program	<input type="radio"/> Enter the simulation code in the textbox:		
9		<pre>SimAL WeatherDemo { p3_svc = SETUP("ServiceP3") psl_svc = SETUP("ServicePsl") vite_svc = SETUP("ServiceVite") notification_svc = SETUP("ServiceNotification") wforecast_svc = SETUP("ServiceWeatherForecast") wprocess_svc = SETUP("ServiceWeatherProcess") psl = psl_svc.INVOKE("to-psl", %%) wf = wforecast_svc.INVOKE("RetrieveForecast", %%) wp = wprocess_svc.INVOKE("ProcessForecast", wf_arho, arho, %%) p3 = p3_svc.INVOKE("reschedule", wp_arho, %%) vite = vite_svc.INVOKE("simulate", arho1, %%) notif = notification_svc.INVOKE("psl.stanford.edu", 8250,</pre>		
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28	<input type="radio"/> <input type="button" value="Select Simulation File"/>	File Name:	C:\Develop\SimAL\P3Arg_10.txt	
29				
30				
31		<input type="button" value="Simulate"/>		
32				



Dynamically Acquire Online Information

Today	Tomorrow	Thu	Fri	Sat
Scattered Thunderstorms High: 90 Low: 74	Scattered Thunderstorms High: 89 Low: 74	Isolated Thunderstorms High: 88 Low: 75	Scattered Thunderstorms High: 87 Low: 74	Scattered Thunderstorms High: 87 Low: 74

Featured Forecasts at weather.com: [Vacation Planner](#) | [Garden Conditions](#)
[Pollen Counts](#) | [Golf Conditions](#) | [Desktop Weather](#)

More Current Conditions

Feels Like:	84°	Dewpoint:	73°
Barometer:	29.91 in and rising	Wind:	SE 8 mph
Humidity:	69%	Sunrise:	7:09 am
Visibility:	Unlimited	Sunset:	7:16 pm

Translate into XML

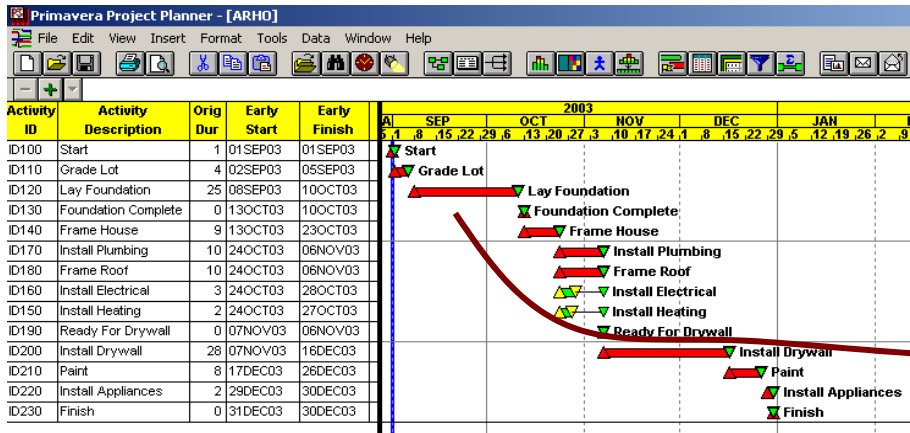
```

<?xml version="1.0"?>
<WeatherReport>
<weather date="2003-9-23">
<location>
<zipcode value="33410" />
</location>
<conditions value=" Isolated
thunderstorms early, mainly cloudy
overnight with a few showers" />
<temperature>
<temp low c="23.3" f="74.0" />
<temp high c="32.2" f="90.0" />
</temperature>
.....
</weather>
.....

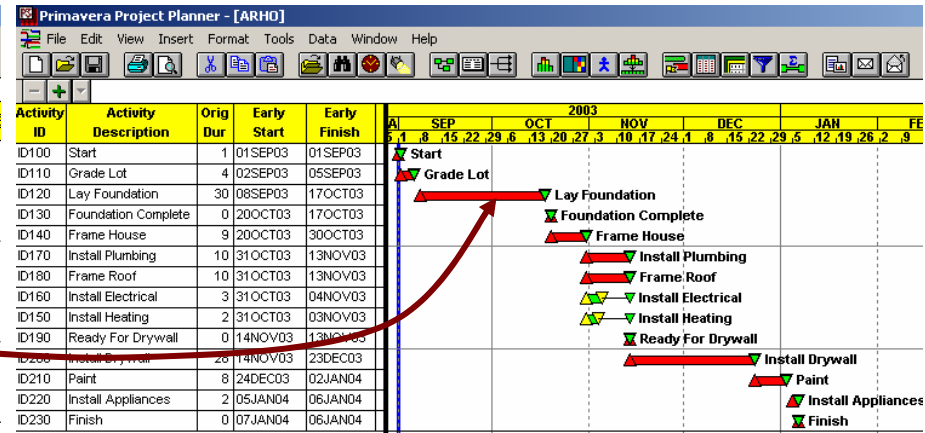
```



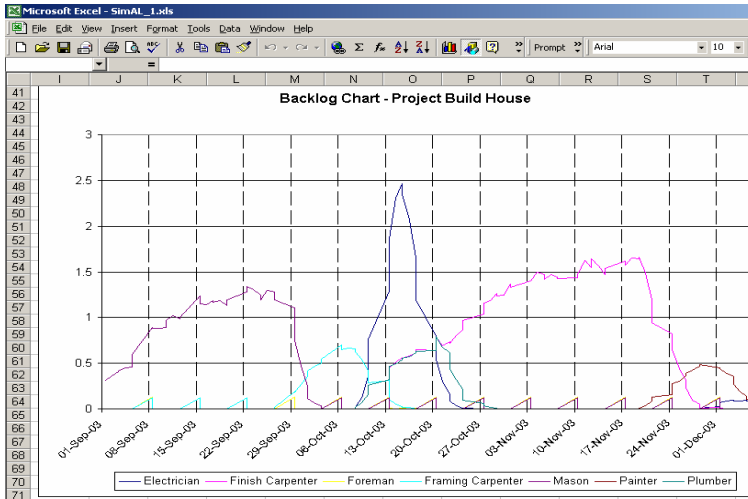
Comparison of Original and Updated Information



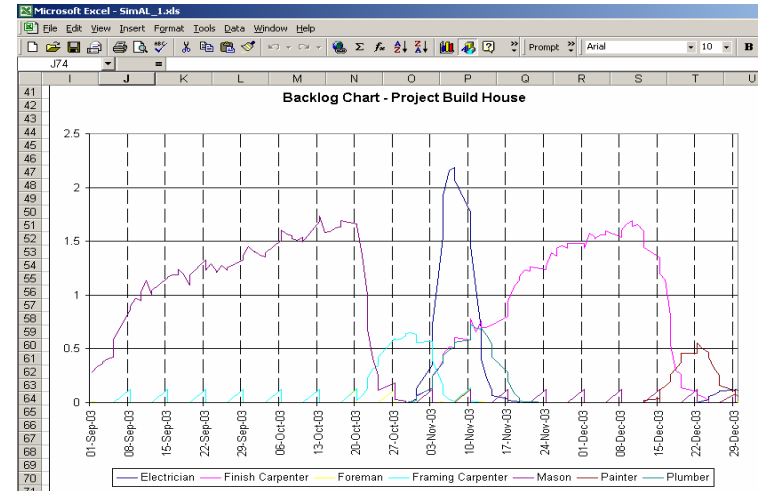
Original Schedule in Primavera P3



Updated Schedule in Primavera P3



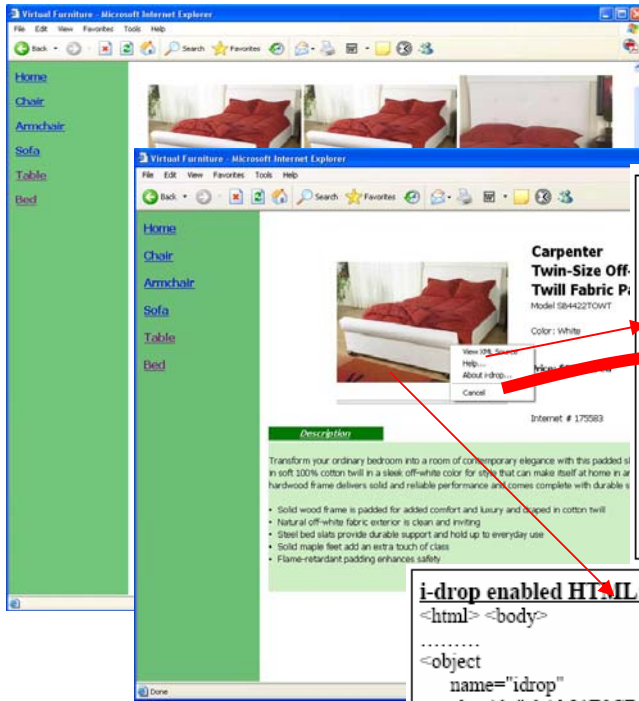
Original Backlog Chart Simulated using Vite and Displayed in Excel



Updated Backlog Chart Simulated using Vite and Displayed in Excel



Interoperability with Online Resources

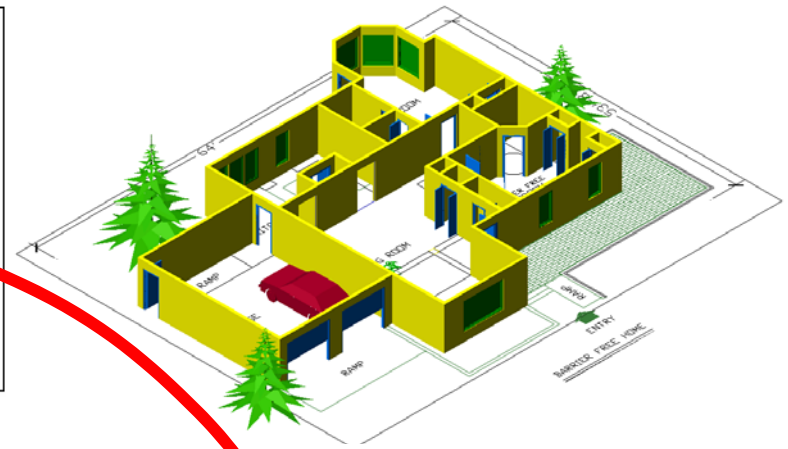


XML package file:

```
<?xml version="1.0"?>
<package
  xmlns="x-schema:drop-schema.xml">
  <proxy defaultsrc="data/bed1.jpg">
  </proxy>
  <dataset defaultsrc="Portrait K1456.max">
  <datasrc clipformat="CF_IDROP.max">
  <datafile src="IK-CA-0789.max"/>
  </datasrc>
  <datasrc clipformat="CF_IDROP.dwg">
  <datafile src="IK-CA-0789.dwg"/>
  </datasrc>
  </dataset>
  </package>
```

i-drop enabled HTML:

```
<html> <body>
.....
<object
  name="idrop"
  classid="clsid:21E0CB95-1198-4945-A3D2-4BF1-95F78"
  width="250" height="250">
  <param name="background" value="background.jpg">
  <param name="proxyrect" value="0,0,230,230">
  <param name="griprect" value="0,0,230,230">
  <param name="package" value="data/bed1.xml"/>
  <param name="validate" value="1">
  </object>
.....
</body></html>
```



Block Reference

General

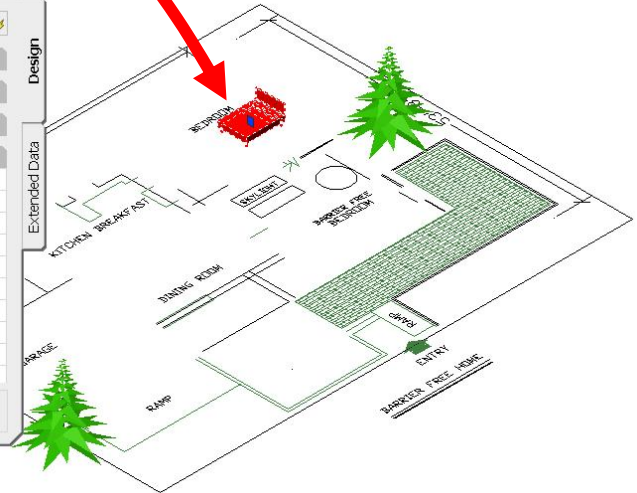
Geometry

Misc

Attributes

DIMENSION	65"x44"x6"
PRODUCTCODE	IK-CA-0789
MANUFACTURER	Carpenter
PRODUCT	Bed
TRADENAME	
MODELNUMBER	SB4422TOWT
MATERIAL	Wooden
SOLDBY	IKEA
PRICE	599,00
COLOR	White

Extended Data

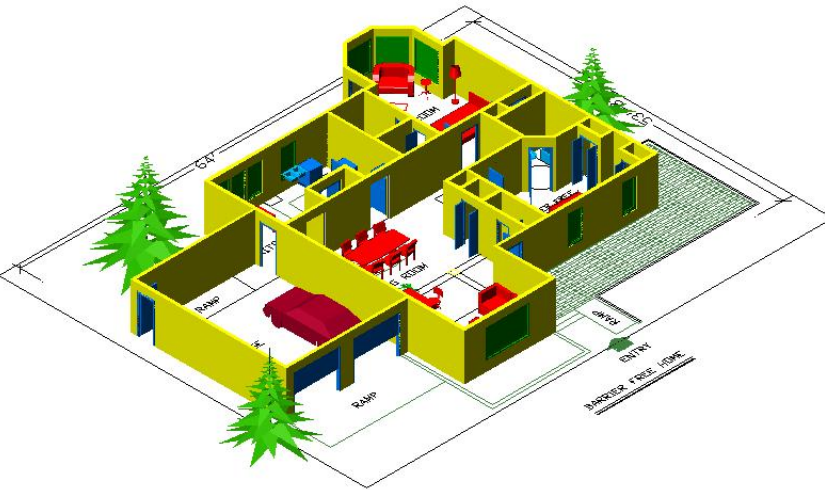


Autodesk's i-drop :

- web page → modified HTML file
- enabled object → XML package file



Generating Procurement Lists



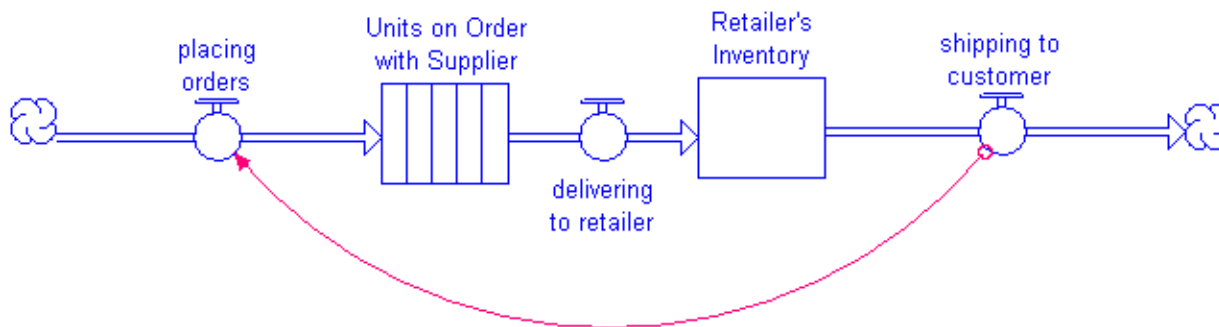
Microsoft Excel - AutoCAD inventory (Feb)

File Edit View Insert Format Tools Data Window Help Adobe PDF

Update inventory Compare inventory 100%

B27 Dishwasher

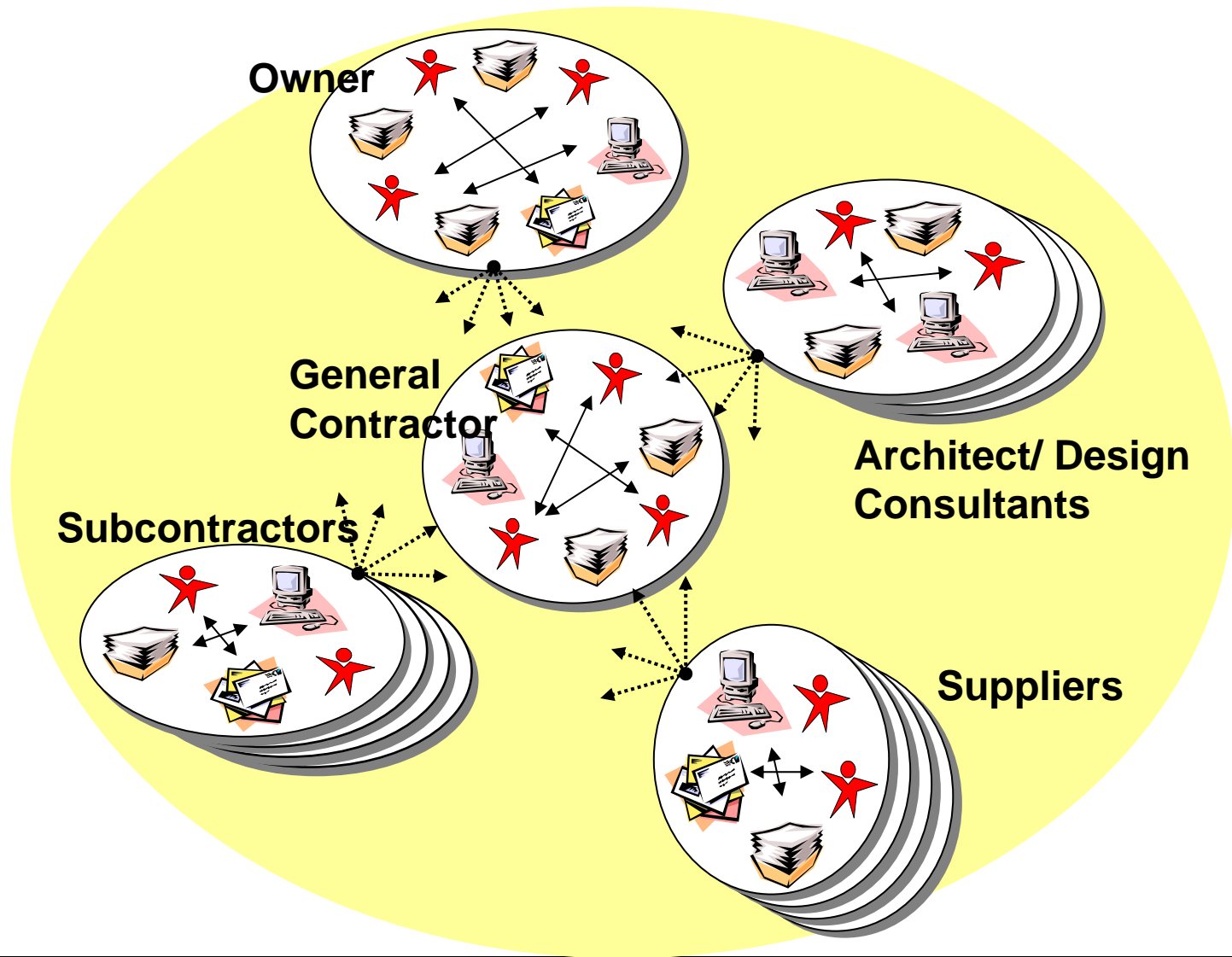
Current Inventory Required											Updated on 2/10/2006 16:39	
Product Code	Product	Manufacturer	Trade Name	Model Number	Material	Supplier	Price	Color	Quantity	Total # of It		
IK-CA-0789	Bed	Carpenter		SB4422TOWT	Wooden	IKEA	\$599.00	White	2	\$1,198.00		
IK-CA-9034	Chair	Carpenter	CIFE		Wooden	IKEA	\$69.99	Khaki	7	\$489.93		
HD-CA-0029	Table	Carpenter	Patricia	12193-69	Wooden	HomeDepot	\$499.00	Dark Brown	1	\$499.00		
IK-UN-3482	Table	Carpenter	Tresidder	MOK-9	Plastic	IKEA	\$99.99	Red	1	\$99.99		
HD-SO-7872	Sofa	Softy	Tri-soft		Leather	HomeDepot	\$2,399.99	Black	1	\$2,399.99		
HD-SO-9923	Sofa	Softy	Single-soft		Leather	HomeDepot	\$899.99	Black	1	\$899.99		
HD-SO-8973	Love Seat	Softy	Single-com		Leather	HomeDepot	\$1,299.99	Red	1	\$1,299.99		
IK-CA-8723	Table	Carpenter	Patricia	12188-0A	Wooden	IKEA	\$149.99	White	1	\$149.99		
IK-UN-0093	Lamp			P03797989	Metal	IKEA	\$129.99	Silvery	1	\$129.99		
IK-UN-0020	Sink		UNAKO	E121K	Metal	IKEA	\$100.00	Silvery	1	\$100.00		
HK-MO-7890	lavatory	Mohla	Comfort	8937HK	Acrylic	HomeDepot	\$340.00	Dark Blue	3	\$1,020.00		
HK-MO-1121	toilet	Mohla		WM-554	Acrylic	HomeDepot	\$279.00	White	3	\$837.00		
HD-MO-2218	bath	Mohla		RTA-23	Acrylic	HomeDepot	\$888.00	Dark Blue	2	\$1,776.00		
HK-MO-6633	Grab Bar	Mohla	Franken	HYAM334	Metal	HomeDepot	\$20.00	Silvery	1	\$20.00		
HK-MO-6630	Grab Bar	Mohla	Franken	HYAM280	Metal	HomeDepot	\$59.99	Silvery	1	\$59.99		
IK-CA-9932	Table	Carpenter	Jackson	TY99U	Wooden	IKEA	\$259.99	Brown	1	\$259.99		
IK-CA-3434	Piano Chair	Carpenter	Jackson	TJ38A	Wooden	IKEA	\$350.00	Black	1	\$350.00		
HD-TP-3343	Refrigerator	Trapot	Tech	KLHE8097202	Metal	HomeDepot	\$538.00	White	1	\$538.00		
HD-TP-7784	Washer	Trapot		HODHL2383	Metal	HomeDepot	\$599.99	White	1	\$599.99		
HD-TP-24578	Dryer	Trapot		WAHDM77682	Metal	HomeDepot	\$369.00	White	1	\$369.00		
IK-SA-1200	Stove	Sarno	Safe	KK-903	Metal	IKEA	\$1,599.99	White	1	\$1,599.99		
IK-OS-7872	Desk	OfficeSmart		AKXEM389	Wooden	IKEA	\$230.00		1	\$230.00		
HD-PO-2304	Television	Polar	Crystal	JX48204H	Plastic	HomeDepot	\$1,399.99	Black	1	\$1,399.99		
IK-OS-3388	Bookshelf	OfficeSmart		BKSEM887	Wooden	IKEA	\$150.00		1	\$150.00		
IK-SA-8973	Dishwasher	Sarno	Speed	LL-802-9B	Metal	IKEA	\$400.00	White	1	\$400.00		



Workflow/
Supply Chain



Next Step: Interoperability and Supply Chain



Interoperability Issues

Multiple Domains :

- Engineering, Manufacturing, Business, ...

Heterogeneous Representations of Ontologies

- Term Difference: (Elevator vs Lift)
- View/Contextual Difference: (Transportation vs Equipment)
- Schema Difference: (BPEL vs PSL vs SWML, etc..)

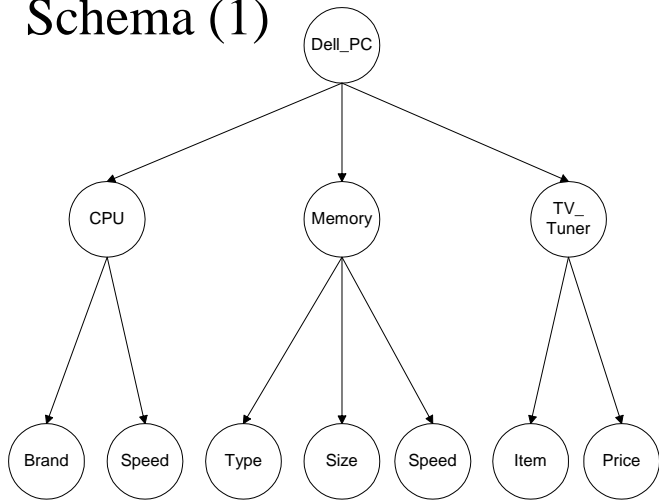
NSF/NIST Collaborative Research Proposal:

*Interoperation, Mediation and Composition of Engineering Services
(Focusing on Supply Chain Applications)*

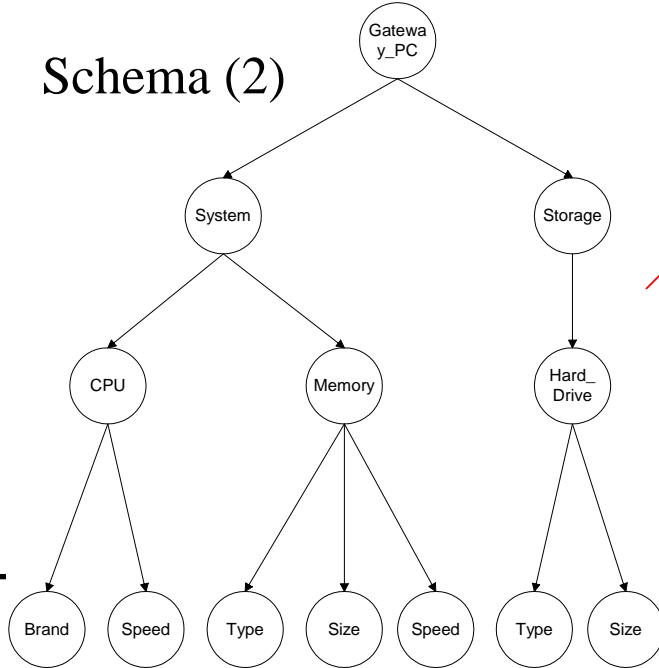


Schema Integration

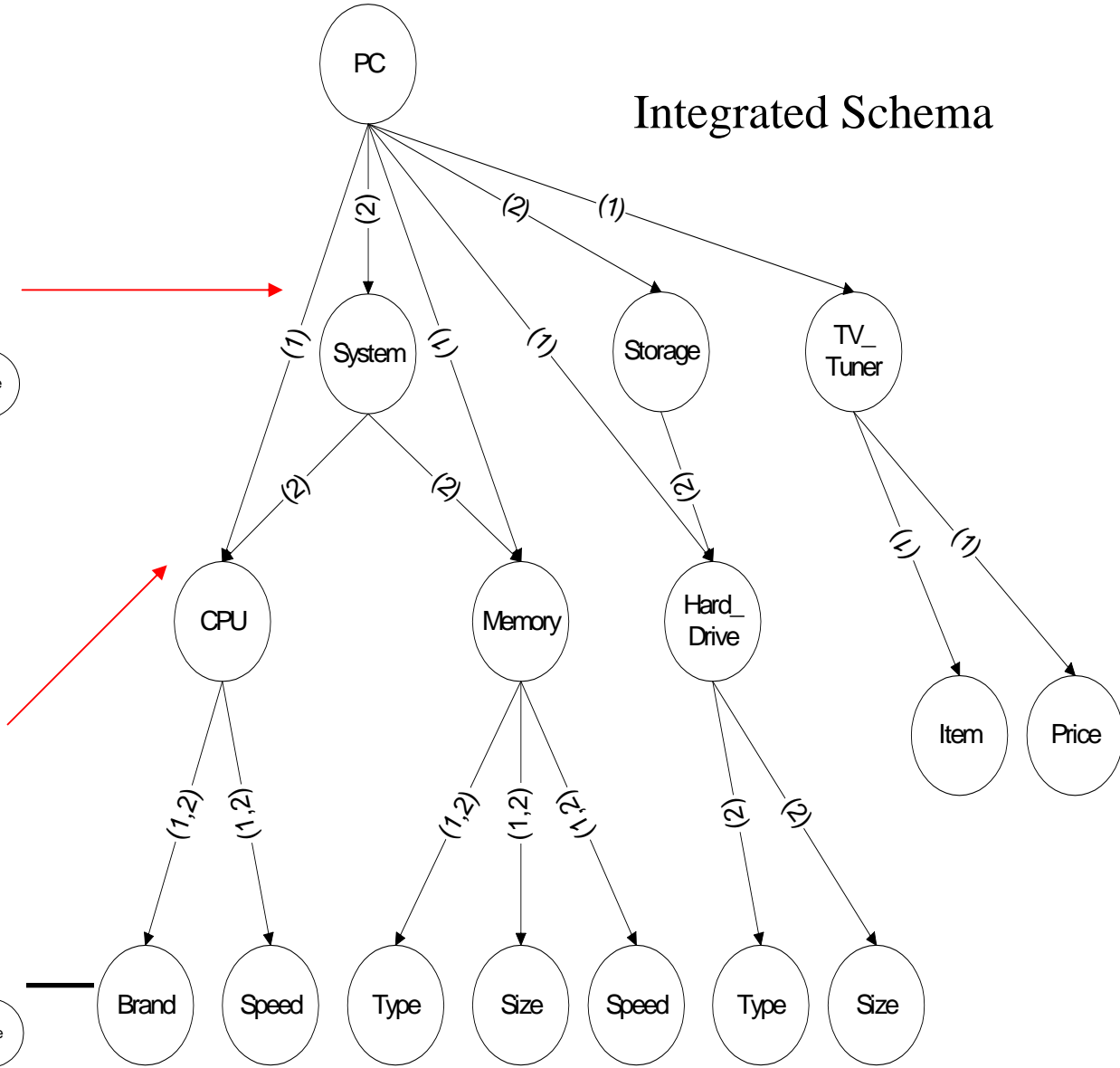
Schema (1)



Schema (2)

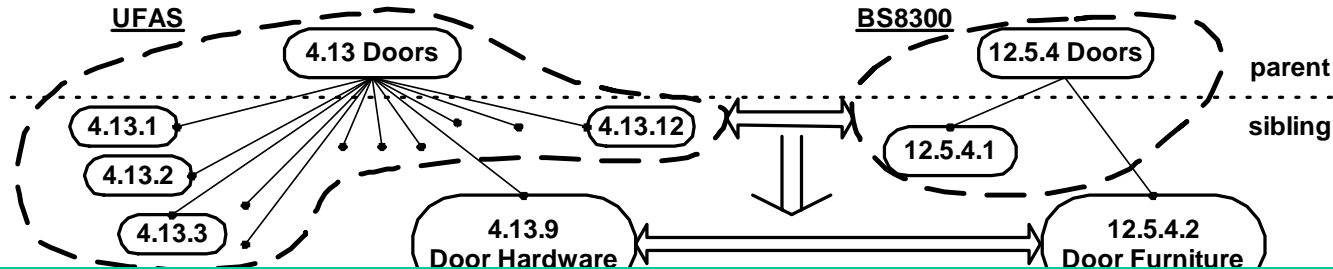


Integrated Schema



Ontology Matching:

Relatedness Analysis – utilizing domain knowledge, text mining and organizational structures



*Discover Related Concepts
among Heterogeneous Ontologies
for Interoperability?*

British Standard 8300

12.5.4.2 Door Furniture

12.5.4 Doors

12.5.4.1 Clear Widths of Door Openings

12.5.4.2 Door Furniture

Door handles on hinged and sliding doors in accessible bedrooms should be easy to grip and operate by a wheelchair user or ambulant disabled person ...

Regulation 2



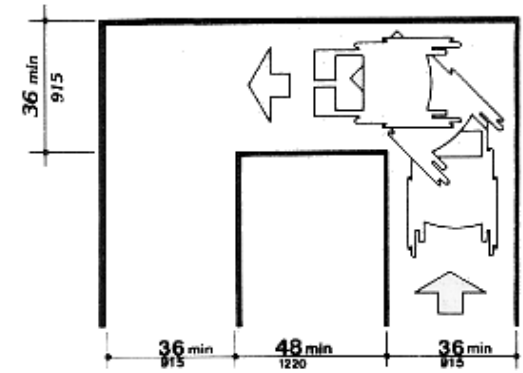
Stanford University / EIG

March 14, 2006

Regulatory Compliance and Engineering Standards

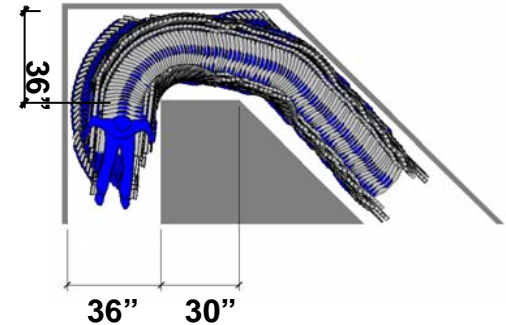
Prescriptive- (Technology-) based Regulations

- Specify exactly how regulated entities conform
- Information needs: Product Model { form, function }



Performance-based Regulations

- Specify a required outcome but not the means
- Information needs: Product Model { form, function, behavior } + simulating/testing ...



Management-based Regulations

- Engage regulated parties in planning and management of processes to fulfill targeted outcome
- Information needs: Product Model { form, function, behavior } + Process (workflow) Specification + Simulation/testing/validation ...

Summary and Remarks

Interoperability Standards

- More than just exchanging data
- Extend application functionalities

Future Works:

- Need to look beyond domain specific application
- Supply chain – life cycle operations, outsourcing, virtual market, ...
- Regulatory environment – e-government services
- Preservation and longevity (digital data, standards,..)
- Impact on next generation *CyberInfrastructure*



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Thank You

Comments and Questions

