Applications of ICT Standards in Engineering

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March 13-14, 2006 Open ICT Ecosystems National Institute of Standards and Technology Gaithersburg, MD 20899

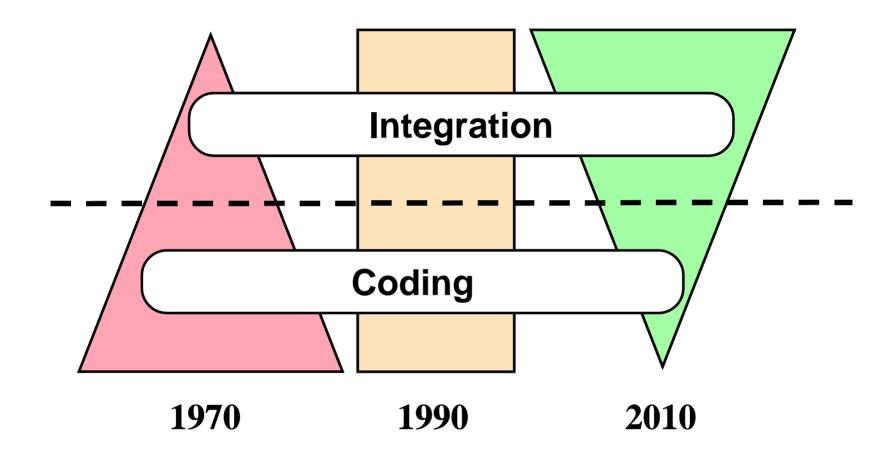


Scope and Outline

- 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

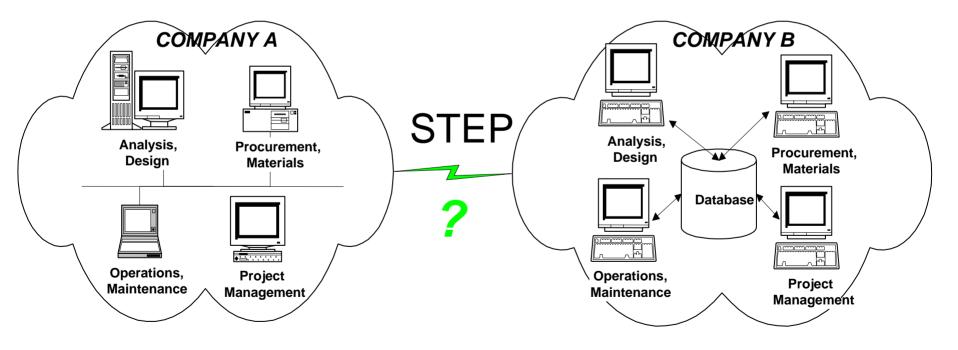
Courtesy of Professor Gio Wiederhold



Data Exchange

A Mechanism for Software Interoperability and Communication within and between Companies

STEP: STandards for the Exchange of Product Data



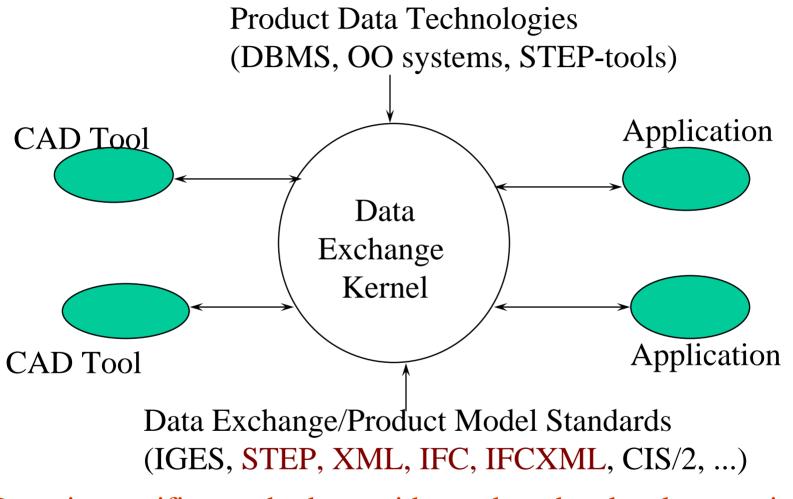


STED Application Drotocold

 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 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 Structured Puilding Elements Using Explicit
Part 2 Part 2 M Part 2 M Part 2 Part 2 Pa	ing Applications Exist
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	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



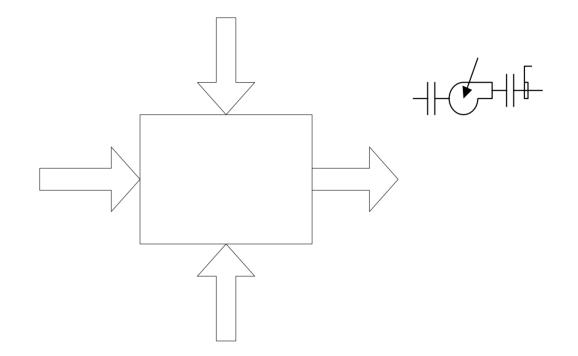
Data Exchange Standards



Domain specific standards provide product data level semantics



Product Model

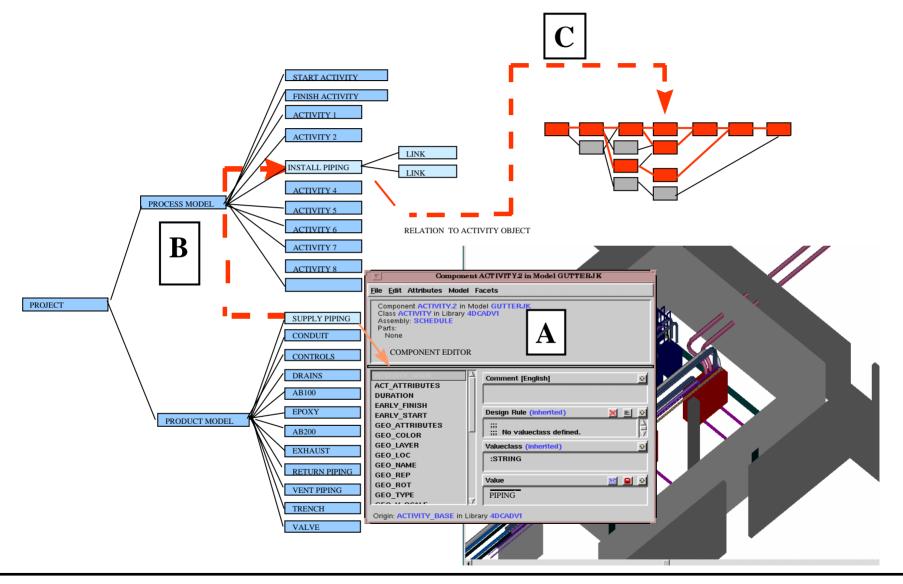


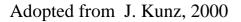
Product Model: {form, function, behavior}



Howie, Kunz and Law, 1997

Product Modeling and Process Specification



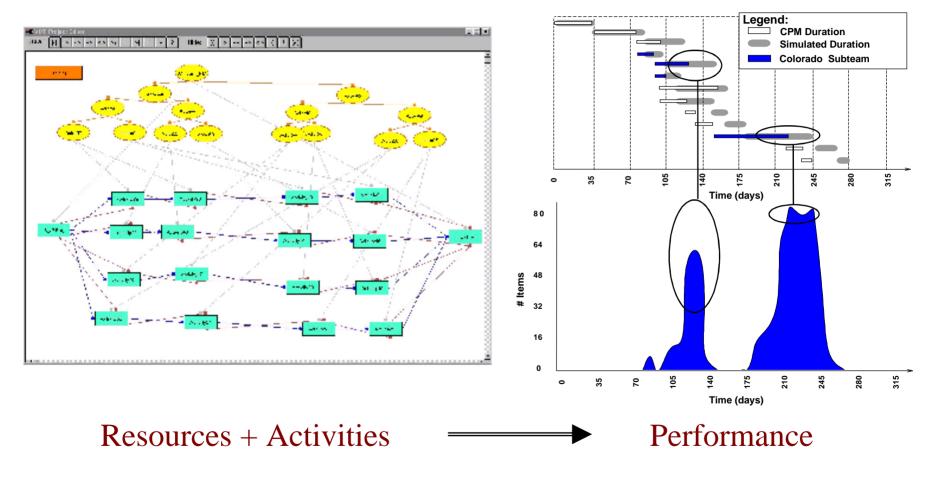




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Process Model

Activities : {Tasks, Schedules, ... } Resources: {Equipment, Organization, Labor, Skills, ... }



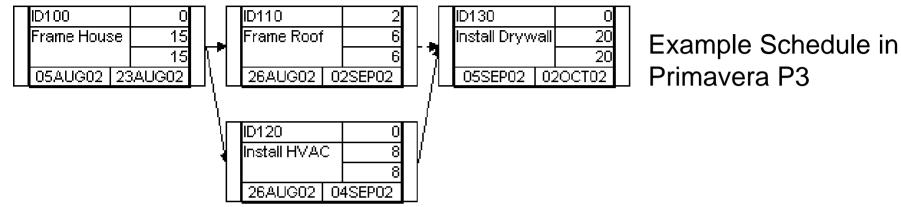


Process Information Model Process Specification Language (PSL)

- **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



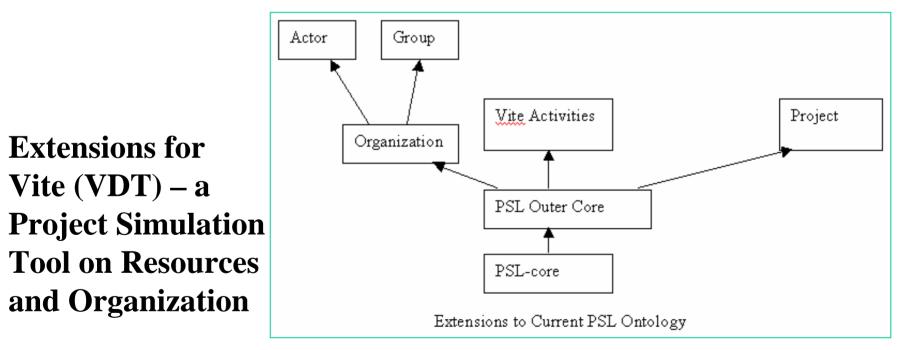
Concepts in Primavera P3	PSL terms
Activity	Activity occurrence
Predecessor, Successor	Activity occurrence, before-start, before-finish, after-start, after-finish
Start to Start	Before-start
Dependency Lag	before-start-delay, before-finish-delay, after- start-delay, after-finish-delay



Ontology Extension for Related Applications

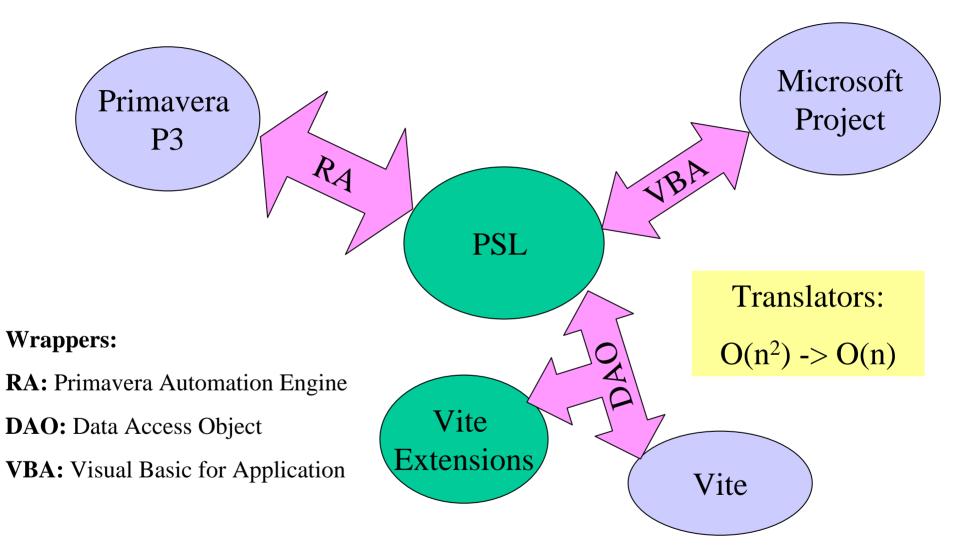
Current PSL Ontology:

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



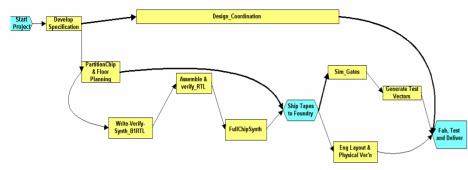


Process Information Exchange





Information Exchange among Applications

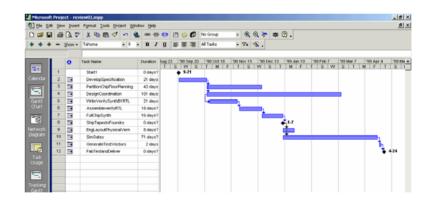


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4 Design_Coordination									
5 Write-Verify-Synth_B1RTL									
6 Assemble & verify_RTL									
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8 Ship Tapes to Foundry					•				
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2 Fab, Test and Deliver								•	
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Gantt Chart In Primavera P3

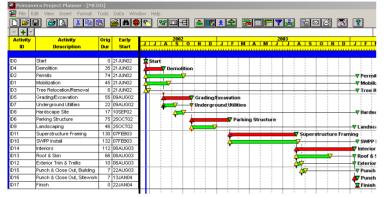


Gantt Chart In Vite

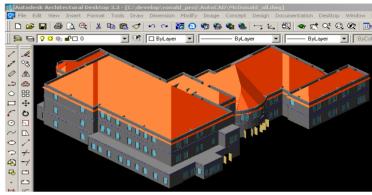
Gantt Chart In Microsoft Project



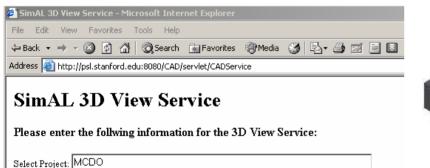
Product + Process Models: Integrating CAD and Scheduling



Project Schedule in P3

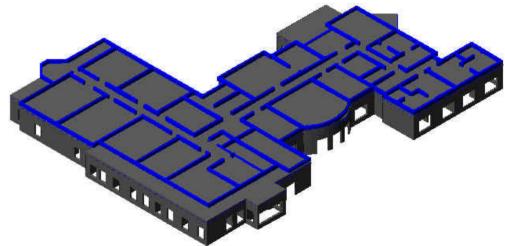


3D Model in Architectural Desktop



Set Target Date: 2003-04-17

Display 3D Model





Ubiquitous Services: Access, Integrate, Coordinate

Communication Devices

Mediators (content and access), DBMS, Information Exchange (PSL, IFCXML, XML, ...)

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Autonomous Engineering and Online (Web) Services



Stanford University / EIG March 14, 2006

Many Proposed Standards for Web Services and Workflow

Examples:

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

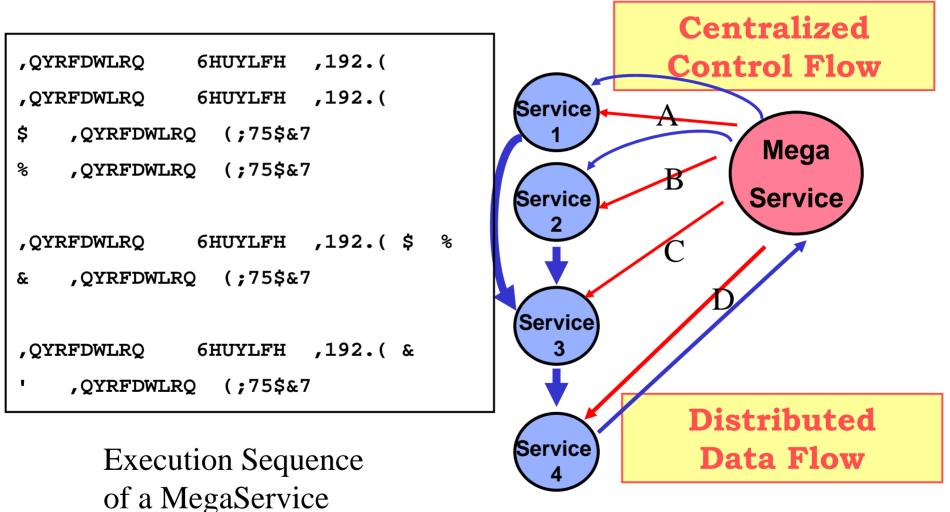
Execution Sequence + Data/Messages

- 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



FICAS: Flow-based Infrastructure for Composition of Autonomous Services



Service Specification: Simulation Access Language

A Simple Easy-to-Use High-Level Language

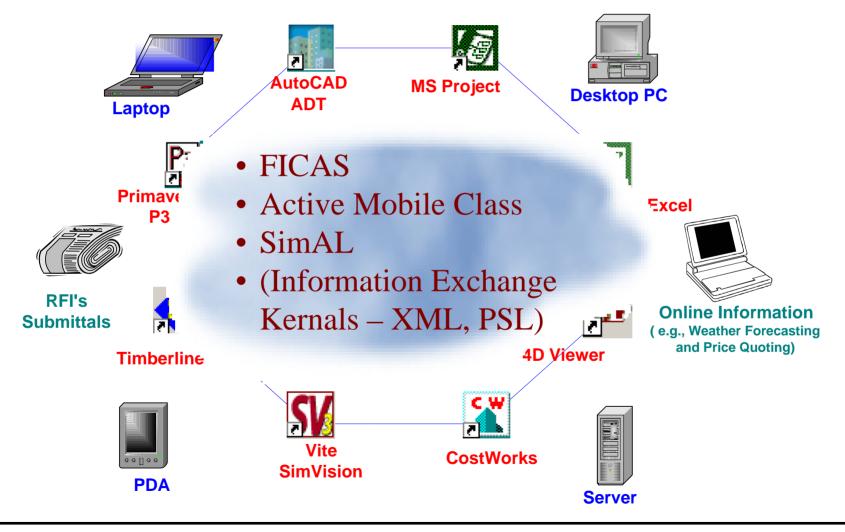
- Coordinating Services and Managing Information Flow
- Simulating and Comparing Scenarios

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.)

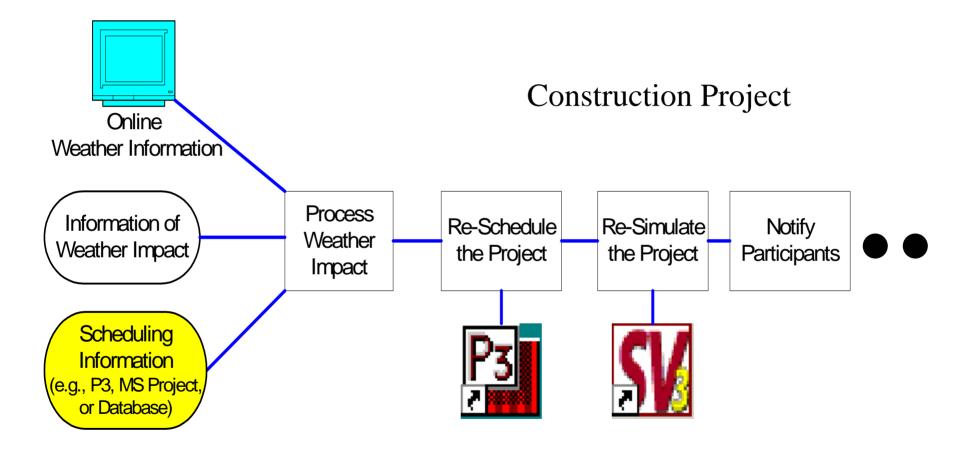


MegaService Simulation Utilizing (Wrapped) Webbased Services





Scenario: Incorporating Online Information into Workflow



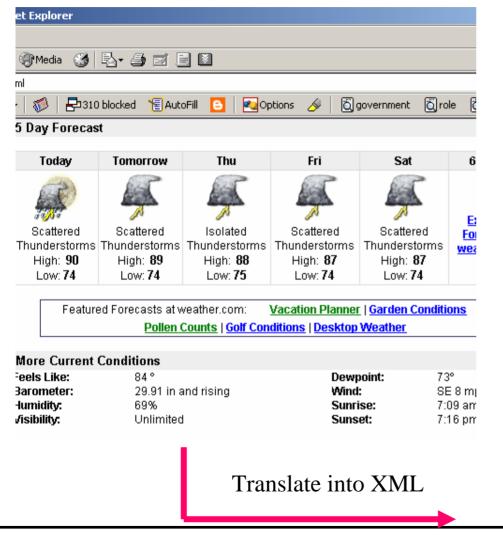


Embedding SimAL Program Segment in Excel

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Dynamically Acquire Online Information



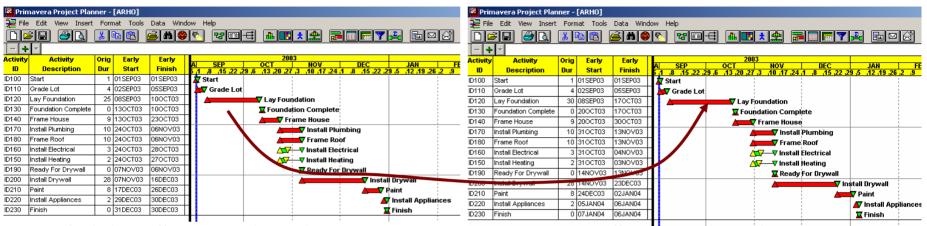
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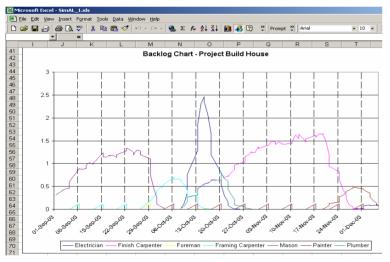
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Comparison of Original and Updated Information

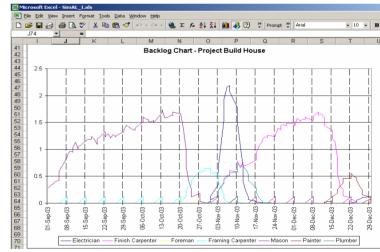


Original Schedule in Primavera P3



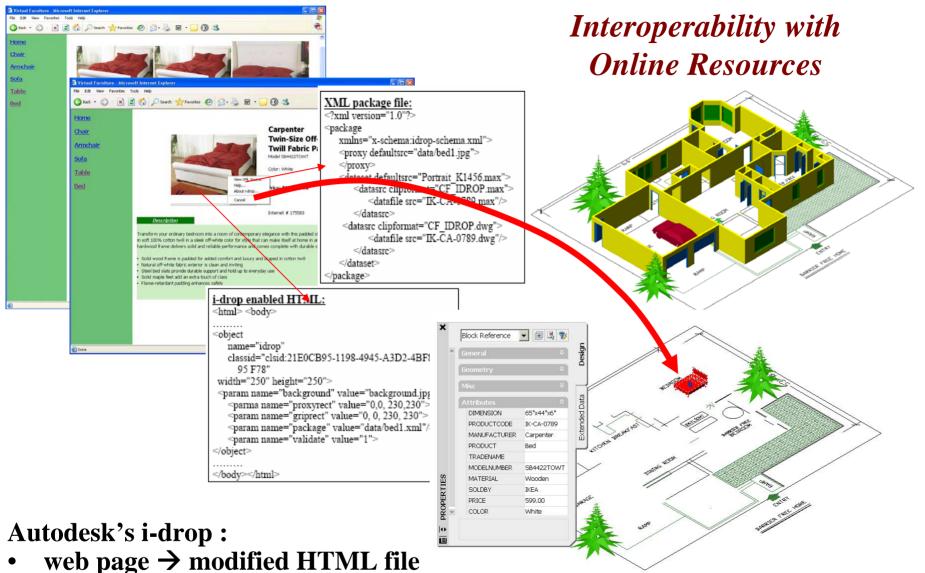
Original Backlog Chart Simulated using Vite and Displayed in Excel

Updated Schedule in Primavera P3



Updated Backlog Chart Simulated using Vite and Displayed in Excel

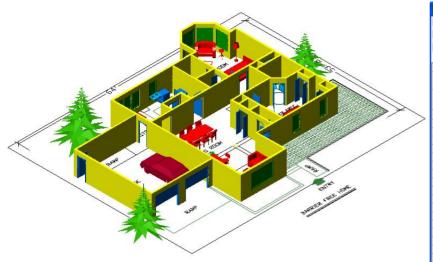




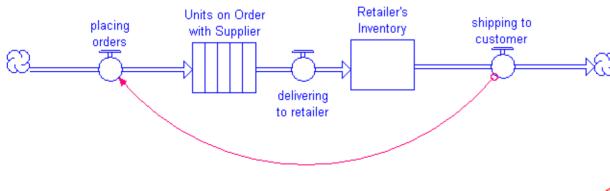
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Generating Procurement Lists



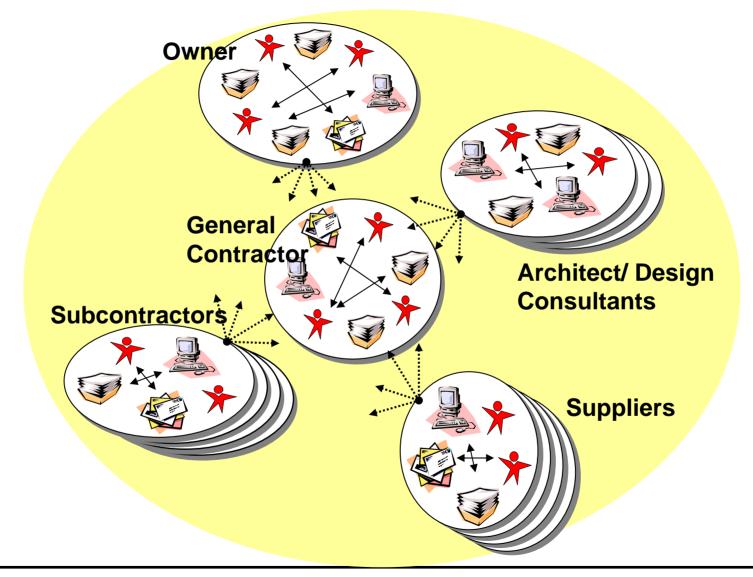
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	Product Product Manufacturer Trade Model Material Supplier Price Color Quantity													
2	Code	Product	Manufacturer	Name	Number	waterial	Supplier	Price	Color	Quantity		Total # of It		
3	IK-CA-0789	Bed	Carpenter		SB4422TOWT	Wooden	IKEA	\$599.00	White	2	\$1,198.00			
4	IK-CA-9034	Chair	Carpenter	CIFE		Wooden	IKEA	\$69.99	Khaki	- 7	\$489.93			
5	HD-CA-0029	Table	Carpenter		12193-69	Wooden	HomeDepot	\$499.00		1	\$499.00			
6	IK-UN-3482	Table		Tresidder	MOK-9	Plastic	IKEA	\$99.99	Red	1	\$99.99			
7	HD-SO-7872	Sofa	Softv	Tri-soft		Leather	HomeDepot	\$2,399,99	Black	1	\$2,399,99			
8	HD-SO-9923	Sofa	Softv	Sinale-soft		Leather	HomeDepot	\$899.99	Black	1	\$899.99			
9	HD-SO-8973		Softy	Single-com		Leather	HomeDepot	\$1,299.99	Red	1	\$1,299.99			
10	IK-CA-8723	Table	Carpenter		12188-0A	Wooden	IKEA	\$149.99	White	1	\$149.99			
11	IK-UN-0093	Lamp			P03797989	Metal	IKEA	\$129.99	Silverv	1	\$129.99			
	IK-UN-0020	Sink			E121K	Metal	IKEA	\$100.00	Silvery	1	\$100.00			
	HK-MO-7890		Mohla		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			
15	HD-MO-2218	bath	Mohla		RTA-23	Acrylic	HomeDepot	\$888.00	Dark Blue	2	\$1,776.00			
16	HK-MO-6633	Grab Bar	Mohla	Franken	HYAM334	Metal	HomeDepot	\$20.00	Silvery	1	\$20.00			
17	HK-MO-6630	Grab Bar	Mohla	Franken	HYAM280	Metal	HomeDepot	\$59.99	Silvery	1	\$59.99			
18	IK-CA-9932	Table	Carpenter	Jackson	TY99U	Wooden	IKEA .	\$259.99	Brown	1	\$259.99			
19	IK-CA-3434	Piano Chair	Carpenter	Jackson	TX38A	Wooden	IKEA	\$350.00	Black	1	\$350.00			
20	HD-TP-3343	Refrigerator	Trapot	Tech	KHLE8097202	Metal	HomeDepot	\$538.00	White	1	\$538.00			
21	HD-TP-7784	Washer	Trapot		HODHL2983	Metal	HomeDepot	\$599.99	White	1	\$599.99			
22	HD-TP-24578	Dryer	Trapot		WAHDM77682	Metal	HomeDepot	\$369.00	White	1	\$369.00			
23	IK-SA-1200	Stove	Samo	Safe	KK-903	Metal	IKEA	\$1,599.99	White	1	\$1,599.99			
24	IK-0S-7872	Desk	OfficeSmart		AKXEM389	Wooden	IKEA	\$230.00		1	\$230.00			
25	HD-PO-2304	Television	Polar	Crystal	JJX48204H	Plastic	HomeDepot	\$1,399.99	Black	1	\$1,399.99			
26	IK-0S-3388	Bookshelf	OfficeSmart		BKSEM887	Wooden	IKEA .	\$150.00		1	\$150.00			
27	IK-SA-8973	Dishwasher	Samo	Speed	LL-802-9B	Metal	IKEA	\$400.00	White	1	\$400.00			
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Workflow/ Supply Chain



Next Step: Interoperability and Supply Chain





Interoperability Issues

Multiple Domains :

• Engineering, Manufacturing, Business, ...

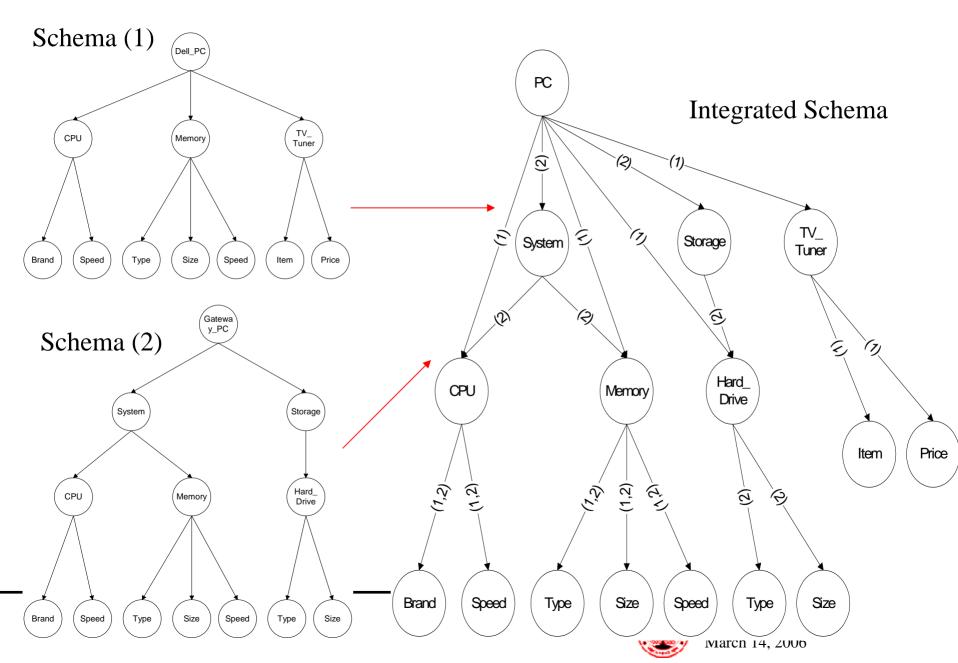
Heterogeneous Representations of Ontologies

- 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)

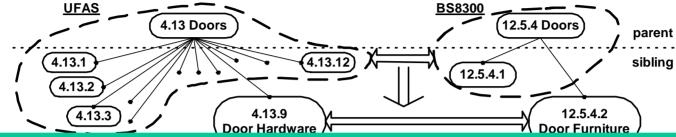


Schema Integration



Ontology Matching:

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



Discover Related Concepts among Heterogeneous Ontologies for Interoperability?



12.5.4 Doors

Regulation 2

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 ...



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 ...



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36"

30"

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*



Acknowledgments



National Institute of Standards and Technology



National Science Foundation



Center for Integrated Facility Engineering

Collaborator:

• Prof. Gio Wiederhold (Computer Science, Medicine, Electrical Engineering)

Former and Current Members of Engineering Informatics Group: Chuck Han, Charles Heenan, Jie Wang, David Liu, Jerome Lynch, Jun Peng, Shawn Kerrigan, Gloria Lau, Jim Cheng, Urmi Holz, Haoyi Wang, Xiaoshan Pan, Yang Wang, Jack Cheng



Disclaimer:

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Thank You Comments and Questions

