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Data Modeling Issues in Product Data Management

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Jeff Davey
Manager
Integrated Engineering Toolset
Siemens Dematic MA

Darrell Raymond
Principal Consultant
Alternative Output

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Agenda

- What is PDM?
  - Functional Components
  - System Architecture
  - Vendors
- Data modeling in PDM
  - Logical and physical design
  - Bills of materials
  - Authorization
- Comments on PDM system design
- Wrap up

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What is Product Data Management (PDM)?

- A PDM system manages all data needed to define product
  - Definitions of parts
  - Bills of materials
  - CAD drawings
  - Specs, manuals, catalogs—many other documents
- Typically both a document and part repository
- Management of change is fundamental (ECR/ECO processes)
- Typically engineering-oriented, rather than manufacturing-oriented
- Evolving into **P**roduct **L**ifecycle **M**anagement

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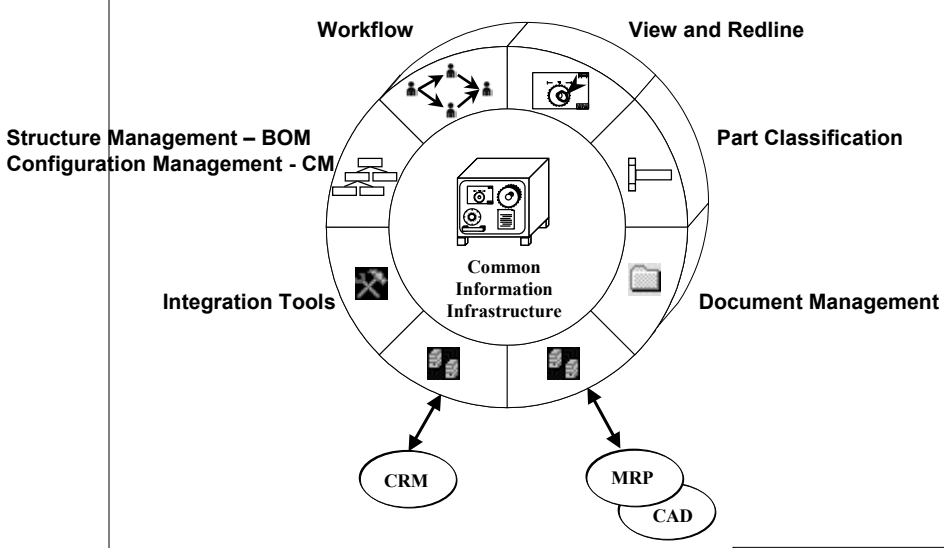
Functional Components of a Typical PDM



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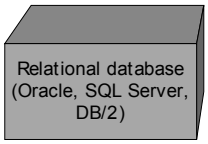
Typical PDM system architecture



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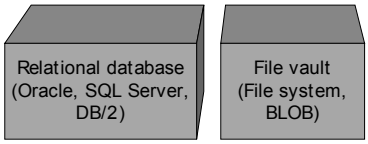

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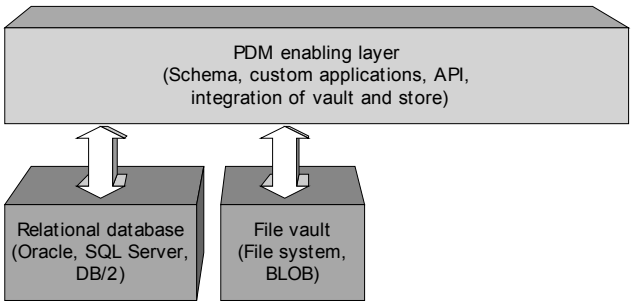

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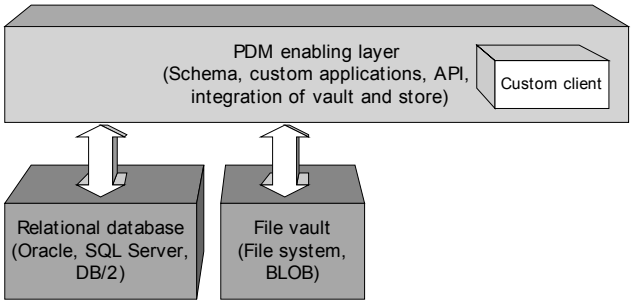

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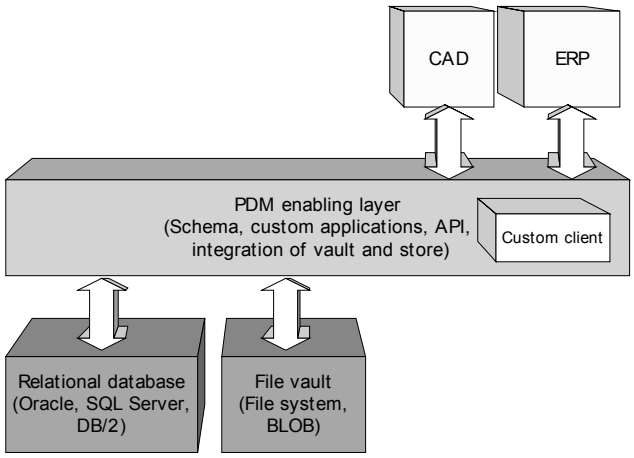
Typical PDM system architecture



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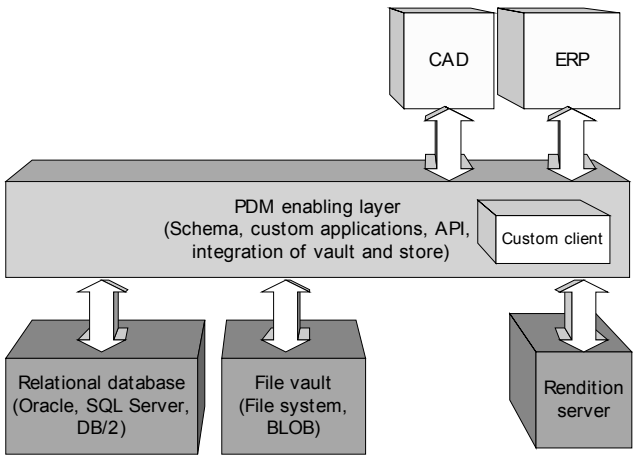

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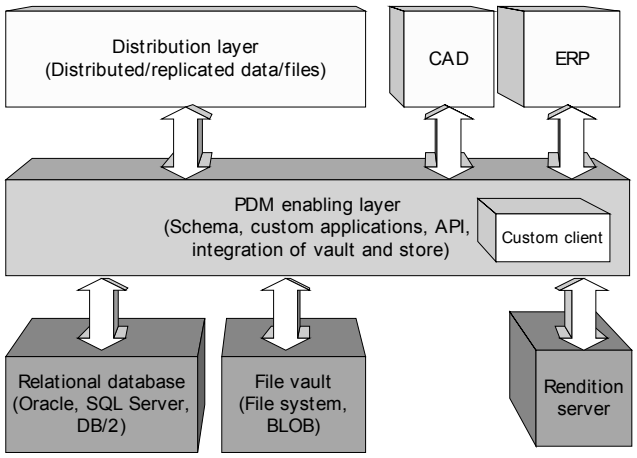

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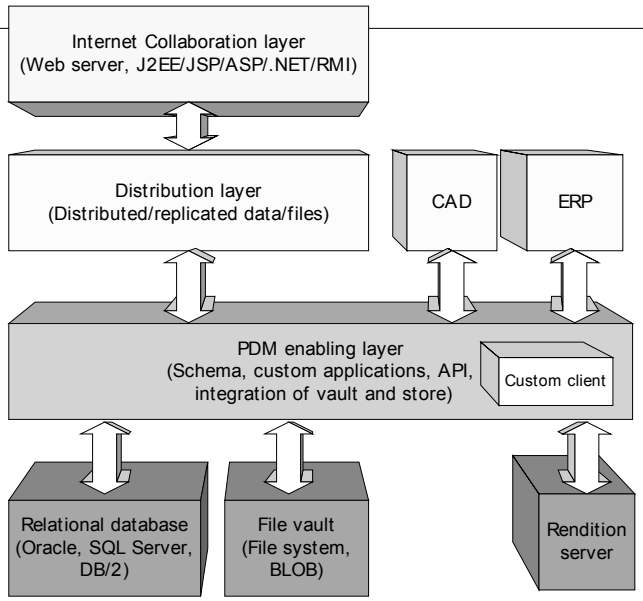

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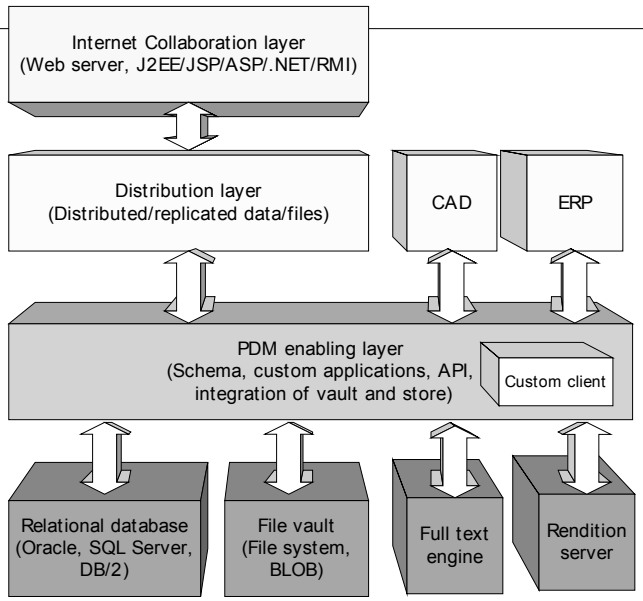
Typical PDM system architecture



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PDM system statistics

Range	Typical
50-40,000 users	2,000
$500k—$10 million	$2 million
10,000—10 million documents	200,000
5,000—1 million part numbers	100,000
100—250,000 items in a BOM	5,000
1-30 levels in a BOM	8
1-4 years in deployment	2
100-1 million reads/day	10,000
10-10,000 updates/day	1,000

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PDM Products and Vendors

- Teamcenter (EDS)
- Windchill (PTC)
- **eMatrix (MatrixOne)—**case study follows
- Agile (Agile Software)
- EnoviaVPM (IBM/Dassault)
- mySAP PLM (SAP)
- Eigner PLM (Eigner + Partner)

- Most CAD/ERP vendors provide some kind of PDM product
- Vendors also try to enter the Knowledge Management, Collaboration, & Portal spaces

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Data Modeling in PDM

- Logical and physical design
- Bills of materials (BOM)
- Authorization

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Meta Model of PDM

- Consists of a set of tables that are definitional to the system. They define not only the data model but also the process and security model
- Characterized by the presence of a base model and the ability to extend standard Entity types to create your own business model (i.e., through use of subtypes)
- Definitional tables drive the necessary physical structure changes to the system
- Dynamic in nature—definition changes do not require significant administrative work
- No two vendors will take the same approach to defining their meta layer. There seems to be no agreed-to best practice approach here
- Typically does not translate into physical tables

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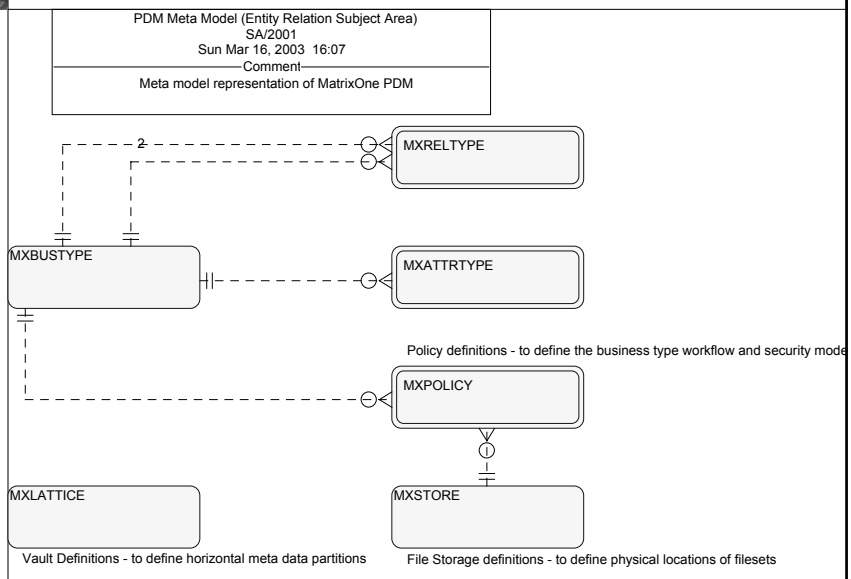
Logical Design in PDM



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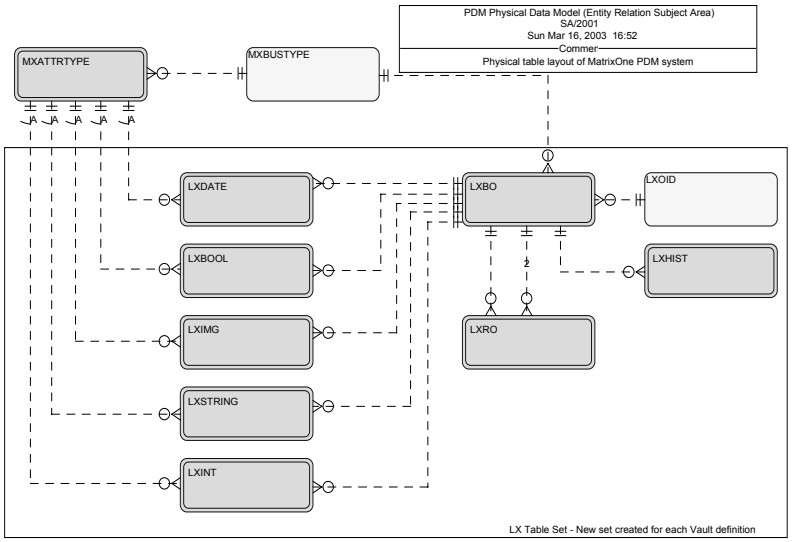
Physical Design in PDM



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Logical and Physical Design in PDM

- In many PDM systems, logical/physical design is considered proprietary information and 'competitive advantage'. Each vendor takes their own approach
- Due to the origins of PDM (Engineering areas) designs are made to adapt to change. i.e., new entity types and attribute types can be added very easily, even on the fly
- Typical business types will have physical instance data in several LX<datatype> tables
- Physical structures are extremely efficient for making single record updates
- Flexibility in the model comes at the price of performance for certain operations
- Query operations that need to return sets of data are very inefficient and require many accesses since data for a single row is spread across several tables

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Logical and Physical Design in PDM

- Updating multiple rows can also be inefficient
- Key tables Object and Relationship (LXBO, LXRO) grow very large and can slow performance if Vaults are not properly managed
- Many types of data are mixed in common object and relationship tables making access tuning difficult
- Horizontal partitioning using the vaults can help to manage object and relationship table sizes and distribute data geographically. However, it can also slow query performance when data must be searched for across several vaults
- Historical change tracking table LXHIST grows extremely large (all object change history is located here)

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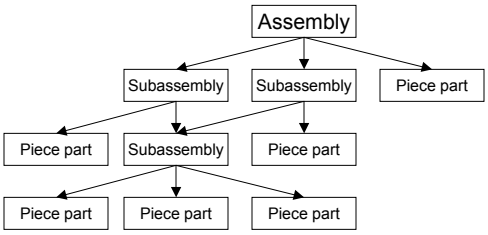
Bill of Materials

- A bill of materials (BOM) is a structured, nested list of all the components of a product
- Mathematically, a BOM is a directed acyclic graph (DAG)



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User's View of a BOM

Level	Pos.	Component Number	Object Summary	ME	TP	Type	Plant	UM	Key	Reference
.1	20	600002-78484947-03	GROBSTRUKTUR MECHANIK	ST	L	ZAUF	5			
..2	1	600002-78511047-03	Vorab/Bestellung Eigen	ST	L	ZAUF	5			
...3	1	01 HIER DIE EINGABEN VORNEHMEN		ST	T					
...3	10	32100943	Antrieb SF 47 DT71D4 MM03/BW1	ST	Z	ZBES	5			M-VORAB
...3	20	32101043	Antrieb R 47 DT90S4 MM11/BMG/HF	ST	Z	ZBES	5			M-VORAB
...3	30	32101143	Antrieb SF 47 DT71D4 MM03/BW1	ST	Z	ZBES	5			M-VORAB
...3	40	32101243	Antrieb SF 47 DT71D4 MM03/BW1	ST	Z	ZBES	5			M-VORAB
...3	50	32101343	Antrieb SF 47 DT80K4 MM05/BW1	ST	Z	ZBES	5			M-VORAB
...3	60	32101443	Antrieb SF 47 DT71D4 MM03/BMG/HF	ST	Z	ZBES	5			M-VORAB
...3	70	32101743	Antrieb SF 47 DT80K4 MM03/BMG/HF	ST	Z	ZBES	5			M-VORAB
...3	90	600002-78505047-12	ROL. 50 NB=600	ST	L	ZAUF	5			M-VORAB
....4	1	600002-78504747-13	ROHR 50 NB=600	ST	L	ZAUF	5			
.....5	1	61084647	Rohr 51 X 7,1 X 473	ST	Z	ZBES	5			
....4	2	78504447	Achse Rolle 50 NB=600	ST	L	IVZ	5			
.....5	1	21243699	Rundstahl H 9 25	M	R	HALB	5	MM	Z2	
....4	3	36816499	Rillenkugellager 6004 2RS	ST	L	HALB	5			
....4	4	34252099	Sicherungsring 20X1,2	ST	L	HALB	5			
...3	100	600002-78505147-03	ROL. 50 NB=750	ST	L	ZAUF	5			M-VORAB
....4	1	600002-78504847-03	ROHR 50 NB=750	ST	L	ZAUF	5			
.....5	1	61084447	Rohr 51 X 7,1 X 623	ST	Z	ZBES	5			
....4	2	78504547	Achse Rolle 50 NB=750	ST	L	IVZ	5			
.....5	1	21243699	Rundstahl H 9 25	M	R	HALB	5	MM	Z2	
....4	3	36816499	Rillenkugellager 6004 2RS	ST	L	HALB	5			
....4	4	34252099	Sicherungsring 20X1,2	ST	L	HALB	5			
...3	110	600002-78505247-01	ROL. 50 NB=900	ST	L	ZAUF	5			M-VORAB
....4	1	600002-78504947-01	ROHR 50 NB=900	ST	L	ZAUF	5			
.....5	1	61084547	Rohr 51 X 7,1 X 733	ST	Z	ZBES	5			

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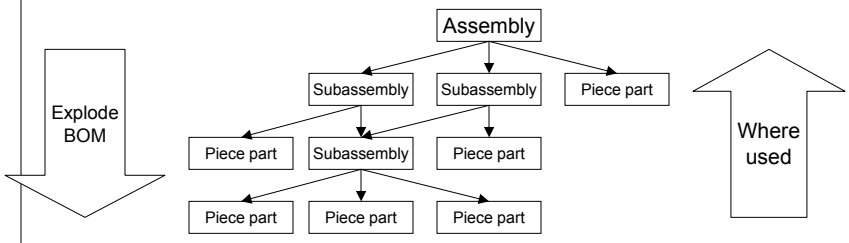
Exploding BOMs

- BOMs need graph operators, but relational algebra is set-based, not graph-based
- The classic BOM queries:



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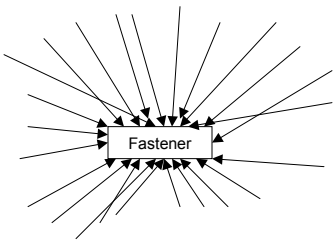
Representing BOMs

- Parts are often represented in one table ('item master': reference LXBO table in MatrixOne model)
- BOM relationships are stored separately ('product structure file': reference LXRO table in MatrixOne model)
- Careful representation is needed
  - Standard parts may have > 100k relationships to other assemblies
  - Poor representation leads to data bloat (don't store where-used—compute it!)



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Exploding BOMs

- Working with product often requires exploding the BOM
  - Recursive query against foreign keys (multiple selects)
  - Selection may be based on effectivity date, part revision, or both
  - Projection on set of required attributes
  - Test of authorization at each object (joins or other selects)
- Problems
  - State-of-the-art in PDM often doesn't do well for BOMs > 1000 parts
  - Result is hard to manage in browsers (20,000 parts ➜ 11 MB HTML file, 140 MB browser footprint)
  - The result—extra resource needed, or BOM explosion is not real-time
- Potential solutions
  - Export data to offline system tuned for graph queries
  - Redundant representation (possibly through materialized views)
  - Separate reporting from browsing
  - Use DB vendor-specific optimizations

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Authorization

- PDM systems increasingly required to enforce security
  - Authentication: who are you?
  - Authorization: can I do operation X to object Y?
- Authentication, data privacy, integrity are solved with standard tools
- Problems in doing authorization 'scientifically'
  - Authorization has few standard tools
  - Authorization is more complex than authentication
  - Authorization is user-driven and user-operated
  - Number of types of objects is increasing, as is number of user groups (customers, vendors, partners, joint ventures, public)
  - Resources available to monitor authorization are being reduced
- Typical PDM situation
  - Ad hoc design
  - Mixture of mechanism, policies, idioms, guesswork
  - No formal assurance

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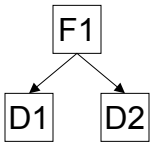
Solving Subtle Authorization Problems

- Consider:
  - Object security is often derived from other objects
  - Typical example: documents in folders

FNAME	PERSON	ACCESS	DOCUMENT
Vendor	Raymond	R	SOW
Vendor	Raymond	R/W	Schedule
Vendor	Davey	R/W	SOW
Vendor	Davey	R/W/E	Schedule



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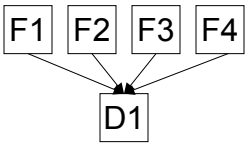
Solving Subtle Authorization Problems

- But suppose documents can be in multiple folders?
  - Where access is not the same in all folders
  - This is another DAG

FNAME	PERSON	ACCESS	DOCUMENT
Vendor	Raymond	R	SOW
Project #12	Raymond	R/W	SOW
Project #13	Raymond	R	SOW
Vendor/F2	Raymond	R	SOW



- Question—what access should Raymond have to SOW?
- Seems to be a question of 'policy'

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Policies

- Most restrictive policy—apply whichever access is most stringent
  - Good: you can restrict access in a single spot
  - Bad: (1) anyone who has access may restrict YOU (2) must search all folders to see if you have access
- Least restrictive model—apply whichever access is loosest
  - Good: (1) Giving access should do *something* (2) don't need to search all folders
  - Bad: No way to be sure that something is restricted without checking all folders
- Both policies are unsatisfactory—as they should be!
- The problem is not which policy to choose—it's data modeling

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Need 4th Normal Form

- There is a *multivalued dependency* `PD ->> B,F`
- Need to normalize into 2 tables:
  - One that captures a person's permissions on a document
  - One that captures folder containment

PERSON	DOCUMENT	ACCESS
Raymond	SOW	R
Raymond	Schedule	R/W

PERSON	DOCUMENT	FNAME
Raymond	SOW	Vendor
Raymond	SOW	Project #13
Raymond	Schedule	Vendor

- The problem can be viewed as one of update consistency
  - By removing redundancy, we eliminate the possibility of inconsistent permissions
  - By providing one place for access permissions, we guarantee access control

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Issues in Authorization

- Authorization is often captured in a mixture of data and code
- System architects often don't have direct access to authorization tables
- Authorization is at a low level—custom mods to vendor's product may not be reflected in new releases
- In off-the-shelf products, authorization changes often require sysadmin access

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Comments on PDM Data Model

- After 10+ years, PDM data model is still evolving
- There is no widespread 'standard' model
- Efficiency of current models leaves much to be desired
- PDM model is based on a graph, not the standard relational set
- Would XML models be better?
  - Data bloat
  - Basic structure is a tree, not a DAG
  - Inherent concept of identity doesn't cross a single XML document

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Wrap up

- Questions?
- Contact us at:

jeffrey.davey@siemens.com
darrell.raymond@sympatico.ca

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