Avancier Methods (AM)

Data Architecture

Data Structures

Long before computers

- Business actors depended business information being.
  - moved in messages (data flows) – often paper
  - stored in memories (data stores) – card indexes and filing cabinets

- Human actors created, processed and moved this data using
  - pens
  - typewriters and
  - snail-mail postal organisations.

The Information Age

- Digitisation of business information using computerised IT.
- Physical forms of business data developed from
  - from human memory and speech,
  - to written records,
  - to bits stored in computer memory and persistent data storage.
- This use of IT massively increased the ability of a business to capture, move, store, process, and analyse business data.
- “Today’s CEOs know that the effective management and exploitation of information through IT is a key factor to business success.” (TOGAF 9.1)

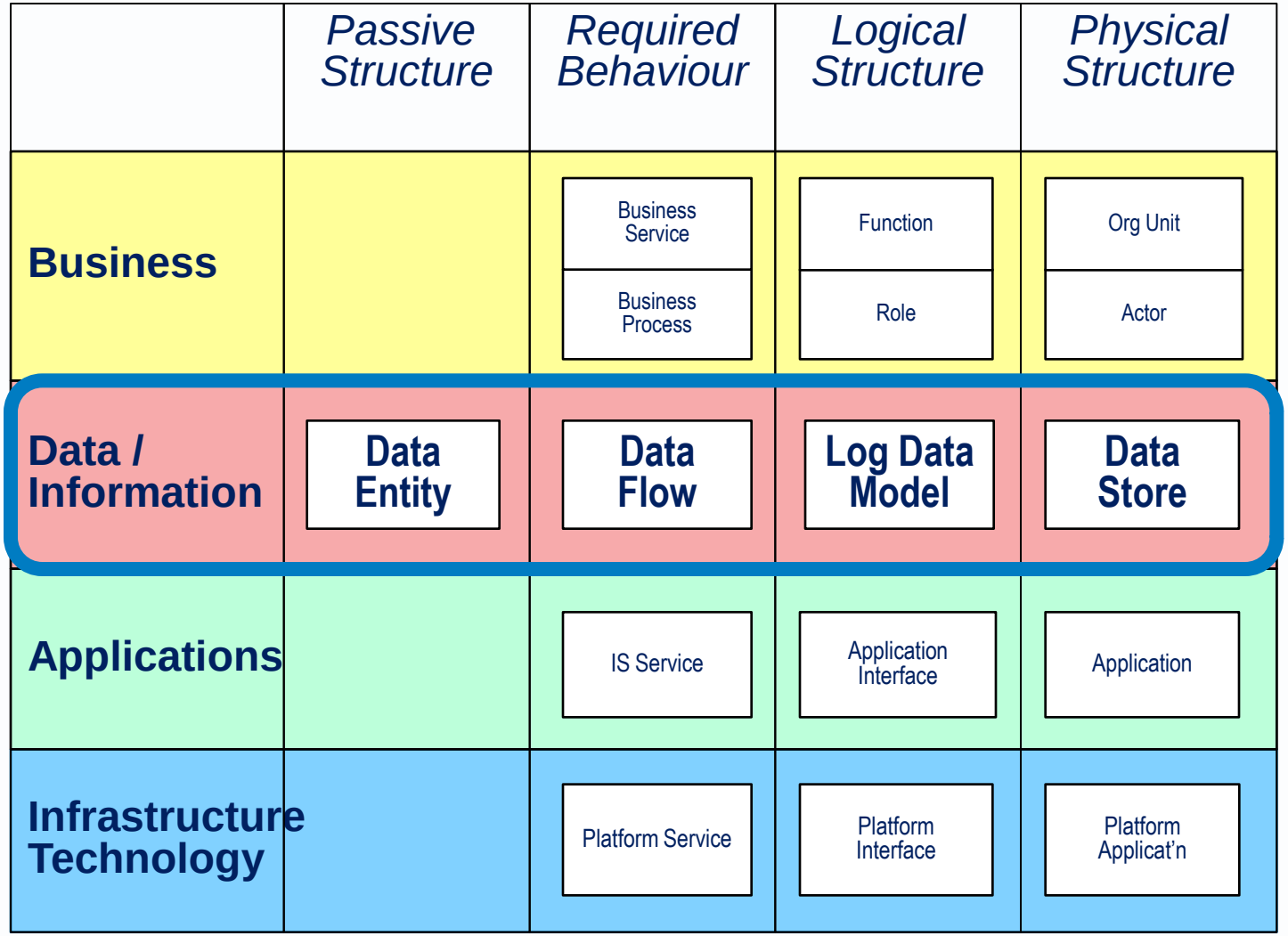
What does an enterprise data architect do?

- Leading bank urgently seeking a proven EA to engage and lead IT projects including
  - the Enterprise Information Architecture
  - information models and flows,
  - data dictionaries, data standards
  - data quality standards and processes

- develop and maintain the logical Enterprise Information Architecture that enables seamless information interoperability of all Bank systems for efficiency and cost-effectiveness.

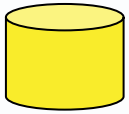
- eutopiaonline.com

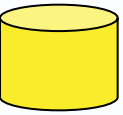
PREFACE



Data architecture

- EA is about business operations that create and use information.
- Data architects are concerned with:

- **Data stores** 
- **Data flows** 
- **Data qualities**



Data stores – data at rest

- Businesses have to store information for future use, in persistent data stores.
- A data store contains a data structure that can be described in terms of inter-related entities.
- Concerns include:
  - The locations, contents and synchronisation of data stores
  - Physical data store forms
  - Data store schema standards
  - Centralised and distributed data storage

TOGAF terminology

- TOGAF uses the term **data component** rather than data store.
- There are two interpretations
  - **A passive data structure**, contained in some kind of data store.
  - **An active data server** (an application component) that provides read/write access to a data structure.

- Either way, the data component contains a data structure that can be described in terms of inter-related entities.

Physical data store forms

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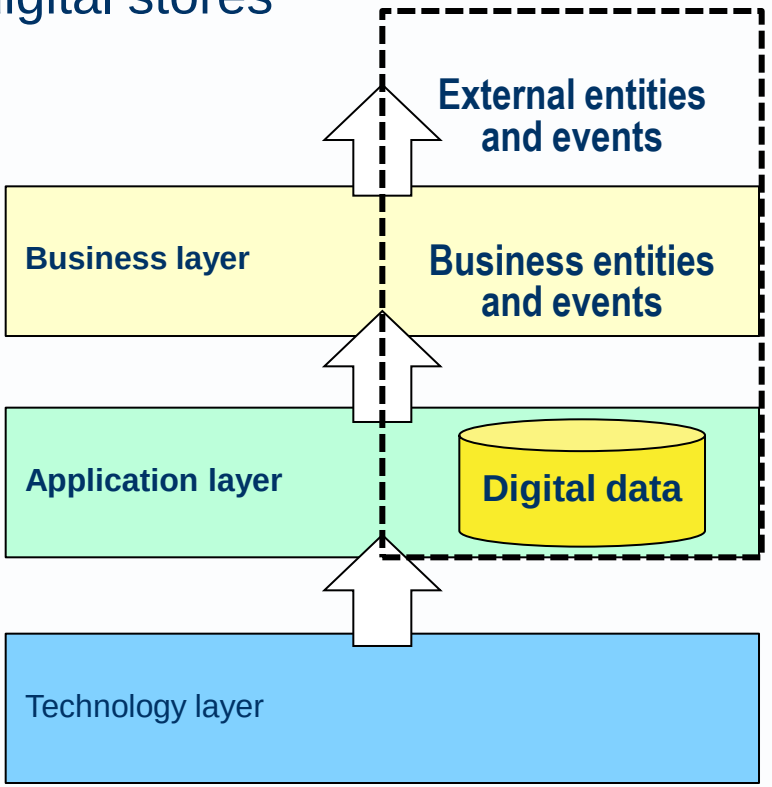
Conceptual	
Logical	
Physical	
Real	

Physical data store forms

- Data architects are concerned with the forms of matter and energy in which information is stored.
- In theory, data architects can design non-digital stores
- In practice most focus on digital ones.



Digital data store forms

- Magnetic disks are currently being replaced by flash storage.

- Flash is optimised for the asymmetric use cases of mobile devices, where data is written few times and read many times.
- So, if you want to find out what may replace flash memory try this:
- http://www.computerweekly.com/feature/Whats-wrong-with-flash-storage-And-what-will-come-after

- Architects have to research physical data storage forms as the need arises.

Data store schemas

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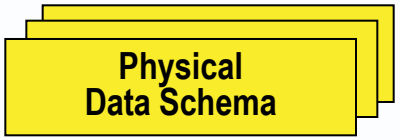
Conceptual	
Logical	
Physical	 ▶ A physical data schema or model defines a data structure in a way that is tuned to specific technologies and NFRs
Real	

Data store schema varieties

- Transactional database

- Data warehouse
- Document store
- Big data store

- Sometimes misleadingly called NoSQL databases
- Need some kind of SQL if they are to support the coding of queries.

Transactional databases (for OLTP)

The focus of EA frameworks

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- Processing requirement
  - many short on-line update transactions (insert, update, delete).
  - short fast queries
  - maintains data integrity (despite concurrent users)
  - throughput measured by number of tpm or tps.

- The OLTP database – typically relational
  - typically a “normalised” relational database
  - typically accessed using SQL
  - holds current data in detail, but only a little history
  - structured and strongly typed business data.
  - Increasingly, solid state drives and in-memory storage
    - enable tens of thousands of transactions per second
    - greatly speed up enquiries and reports.

Data warehouses for OLAP (On-line Analytical Processing)

- Processing requirement
  - often aggregates or summarises a lot of transactional data
  - usually updated by batch data loads.
  - often complex queries
  - focus on response/cycle time.

- OLAP database
  - may have a star or snowflake schema, a key-value store or column store
  - enable analysis and summary reports for management information
  - optimised for data retrieval by the use non-relational data structures (column stores, key value stores etc.).
  - practices includes cleansing, sorting, transforming, aggregating data
  - often associated with specific BI tools.

OLTP v. OLAP (*www.rainmakerworks.com*)

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	OLTP System: Online Transaction Processing (Operational System)	OLAP System: Online Analytical Processing (Data Warehouse)
Source of data	where operational data is captured	consolidates data from the various OLTP Databases
Purpose of data	To monitor and control core business entities and processes	To help with planning, problem solving, and decision support
What kind of data	Reveals a snapshot of the current state of business entities and processes	Gives multi-dimensional views of business entities and processes over their history
Inserts and Updates	Short and fast inserts and updates initiated by end users (capturing events)	Periodic long-running batch jobs refresh the data (capturing entity state copies)
Queries	Relatively standardized and simple queries: return relatively few records	Complex queries that involve aggregating a result from a lot of data
Speed	Typically very fast	Batch data refreshes and complex queries may take many hours; speed can be improved by indexes
Storage space	Can be relatively small if historical data is archived or stored in OLAP database	Larger due to the existence of aggregation structures and history data; requires more indexes than OLTP
Data structure	Highly normalized, many tables	Typically de-normalized, fewer “fact” tables in star and/or snowflake schemas
Recovery	Backup religiously; data loss may entail significant monetary loss and legal liability	Either regular backups, or simply reloading the OLTP data (perhaps using transaction logs)

Document store

- Stores hierarchical data structures
  - Commonly XML or JSON documents

- (A network data model can be divided into discrete hierarchical data structures - to be discussed later.)

Big data store – 3Vs

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- You can store whatever (unstructured or structured) data is captured, then glue different data sets together later

- Volume
  - large volume - many tera/peta bytes collected in minutes.
- Variety
  - unstructured and/or weakly typed data
    - E.g. social media data
  - behaviour that has not traditionally been monitored or directed by business systems.
    - E.g. 1.5 billion pieces of data generated per car per grand prix.
- Velocity
  - Rapidly store a high volume and variety of data
  - Data retrieval may require faster technologies - a variety of data structures and query languages.

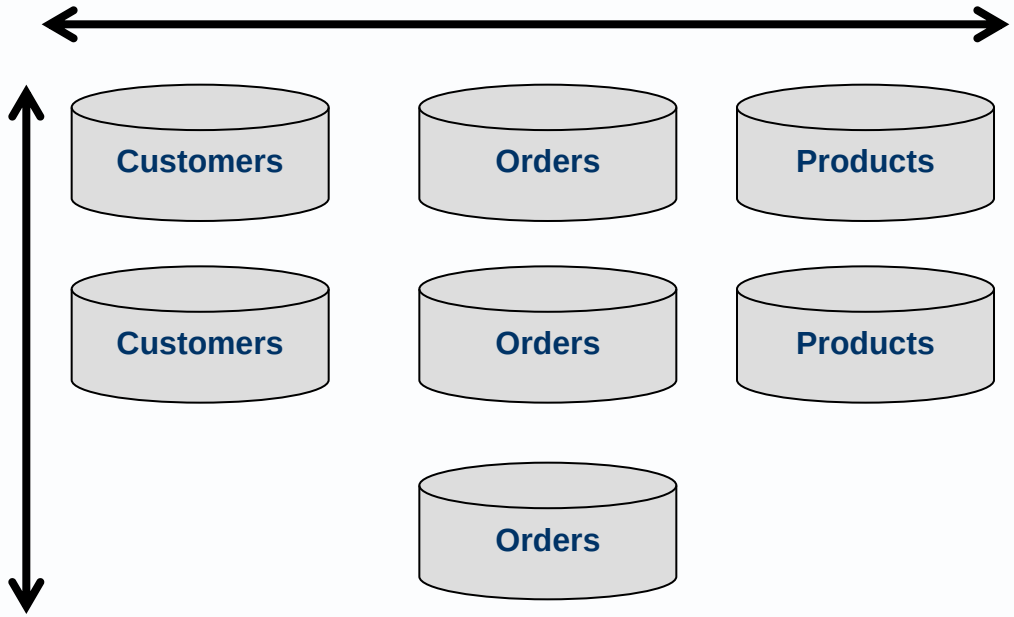
Avancier customers have told me

- Housing association has 1m customers.
  - We collect data from sensors in houses
  - *100 megabytes per customer per hour*

- Rolls Royce get paid for engines by "thrust hours".
  - So they ping their engines once an hour to capture engine data.
  - *2 to 3 terabytes of data per minute of thrust.*

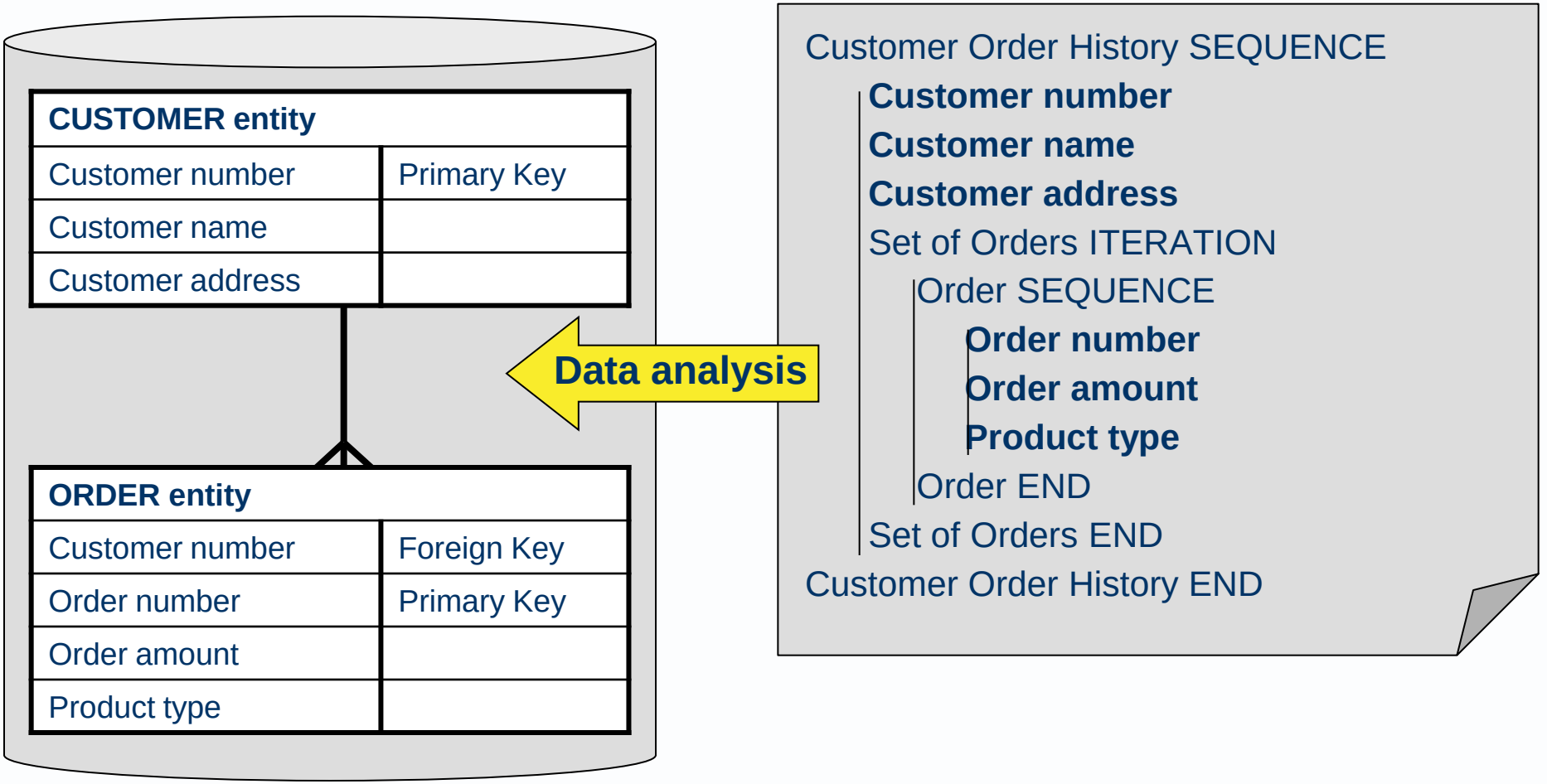
How do Big Data stores handle high data volumes?

- Functional scaling – divides data types



- Sharding – divides a large population across database instances

All data store schemas are designed to enable I/O data flows



Logical data models

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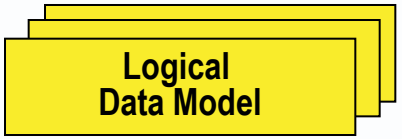
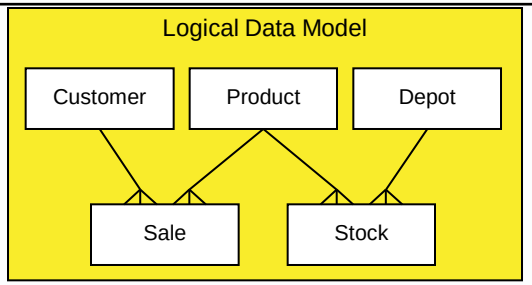
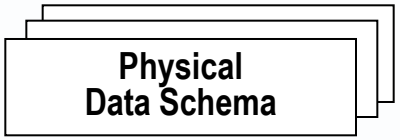
Conceptual	
Logical	 ▶ technology neutral, ▶ but usually focused on one data store 
Physical	
Real	

Three data model notations

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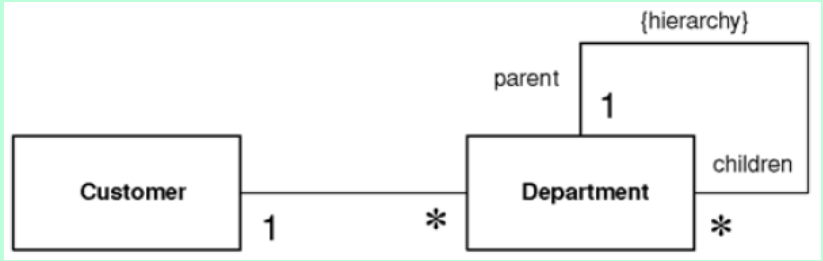
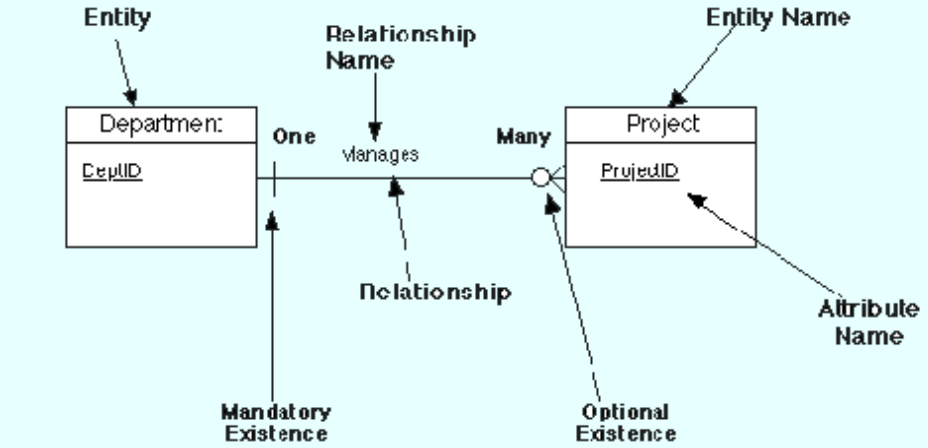
UML

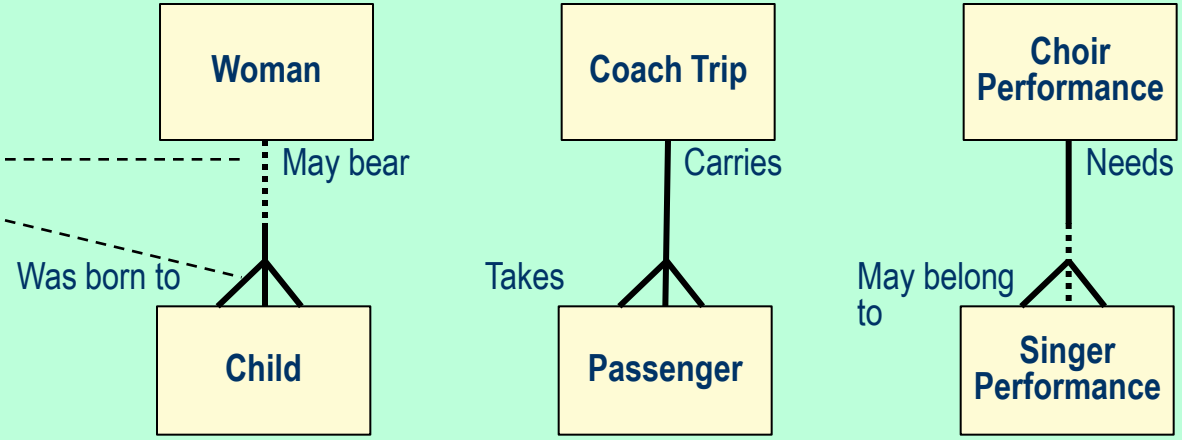


IDEF

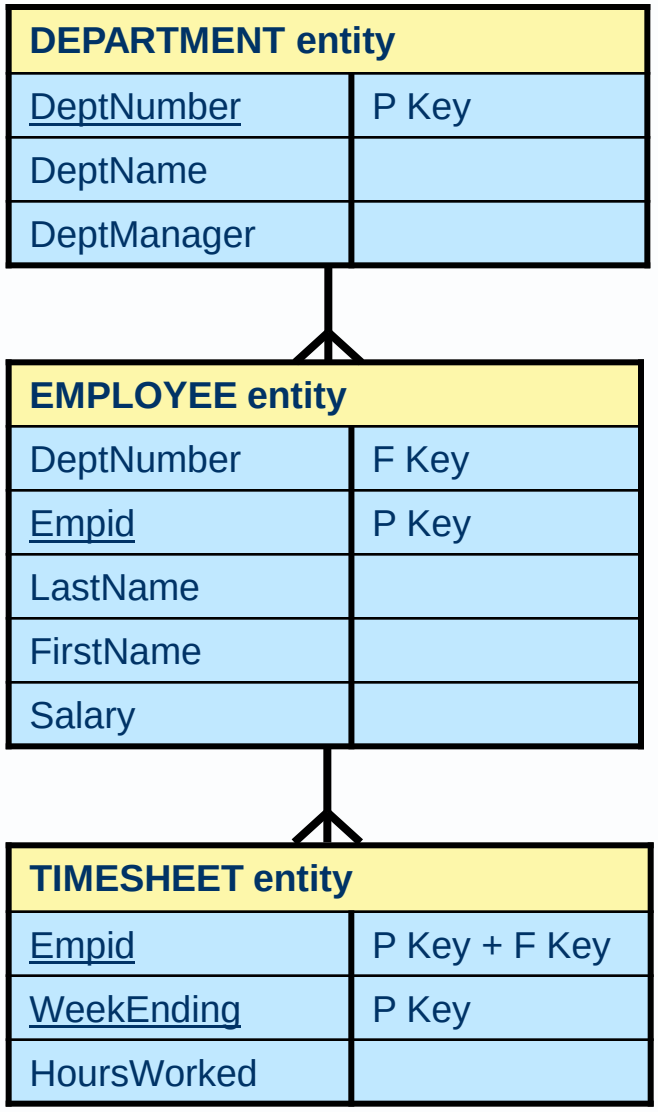


Barker

- Optional
- Multiple



Logical data model



- A model that describes the data that must persist for the processes of a business system to work.
- A network of entities, attributes and relations between entities
- A kind of “domain model” that defines business terms and concepts.
- A data structure that shows entities and events of importance to a business.

- (Not a database schema – unless you want it to be.)

How to partition the network structure of a domain model?

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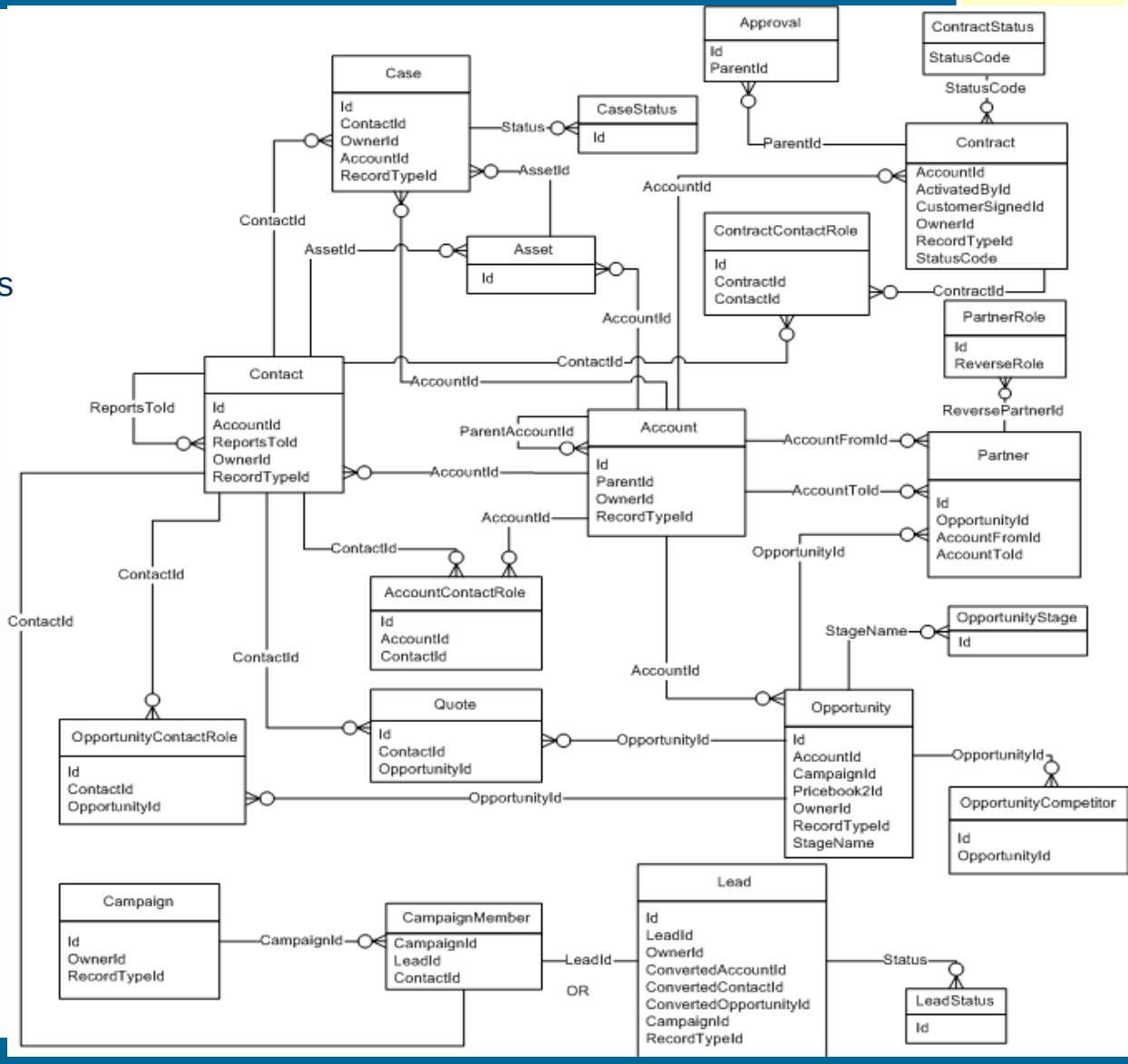
- Note that over time
  - Subtypes tend to become roles
  - Aggregations become associations
  - 1-1 associations become1-N
  - 1 to N become N-to-N w link entities

- The result?
- A network of 1-to-N associations, as in this Salesforce.com domain model



Salesforce.com domain model redrawn (cf. ZF column 1?)

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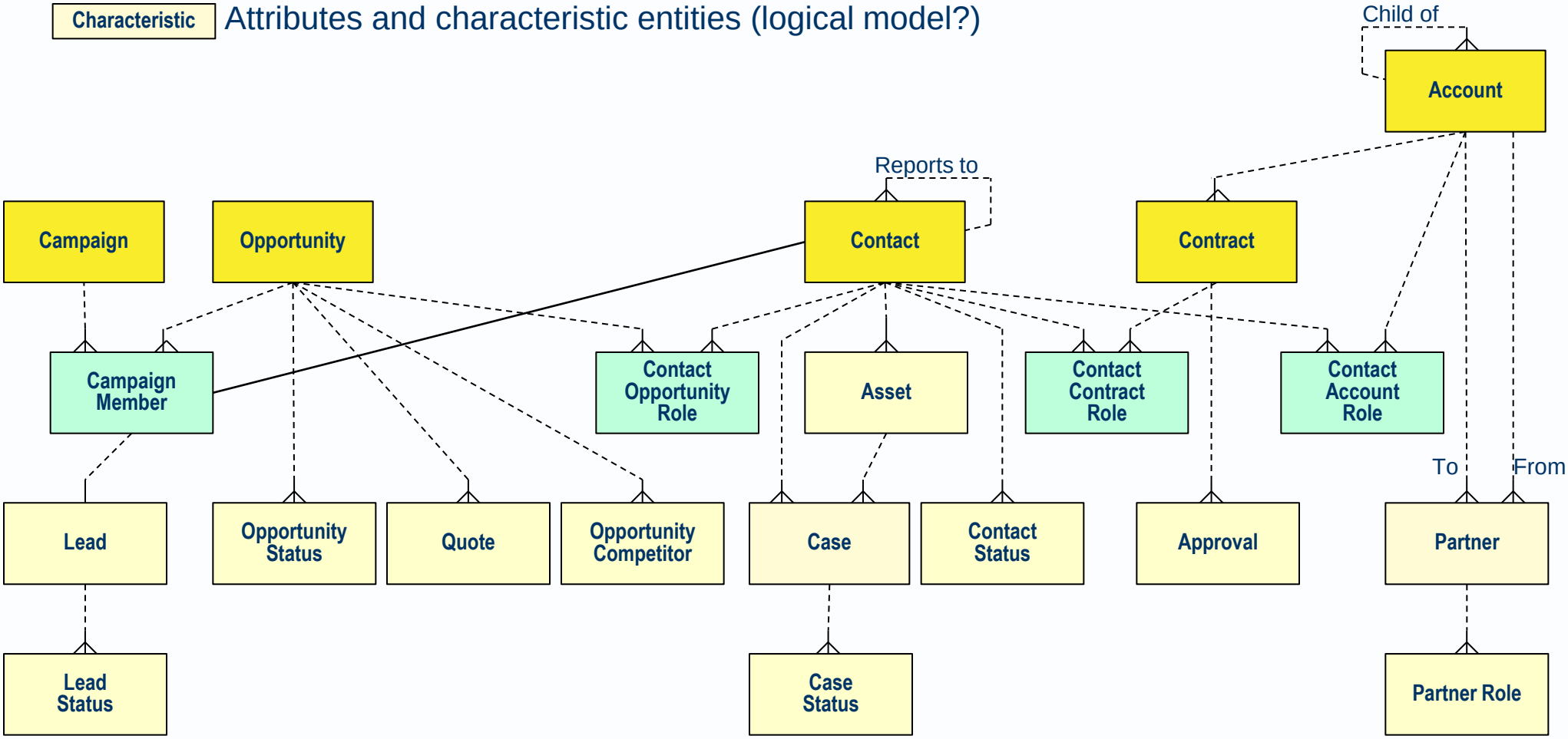
Kernel — Kernel entities

Link — Relationships between them (conceptual model?)

Characteristic — Attributes and characteristic entities (logical model?)



Mapping logical to physical

- TOGAF's "logical data component"
  - is a logical definition of the data in a data store
  - can be documented as a logical data model
  - that is, an entity-attribute-relationship model.

- TOGAF's "physical data component"
  - is a vendor/technology specific realisation of a logical data component.
  - could be database, data warehouse, document store, web information server and transaction log
  - has a technology-specific data schema.

Mapping logical data models to technical-specific data schema

Logical data component	Physical data component			
Logical data model	**CODASYL database schema**	**Relational database schema**	**XML schema (footnote 2)**	**OData-compliant web information server.**
Entities	Records	Tables	Complex types	Entities
Attributes	Fields	Columns	Contained elements	Properties
Relationships	Address pointers	Foreign keys	Contained elements	Navigation properties

Getting data models out of databases

- The challenges of incorporating data structures from often very complex ERP systems into architectures are well known by Enterprise Architects and Data Managers alike.

How many tables SAP's ERP database schema?

- **The sheer number of database tables** is enough to cause headaches, and coupled with customizations and multiple languages it **has a real impact on the effectiveness of your Enterprise Architecture.**

- We'll demonstrate how [to] surface and exploit data models from large, customized systems from SAP® and Oracle® using automatic discovery and intuitive scoping tools.
- Presented by Martin Owen (CEO, Corso), Nick Porter and Roland Bullivant (Silwood Technology)

ODdata - the access protocol for a web-based information server

- Provides a generic way to organize and describe the data structure of any remote data store as a logical data model.

  - An **Entity Type** (Customer, Employee, etc.) is a data structure type consisting of named and typed Properties and with a key.
  - An **Entity** is an instance of an Entity Type.
  - An **Entity Key** (CustomerId, OrderId etc.) is formed from a subset of Properties of the Entity Type.
  - An **Association** defines a relationship between instances of Entity Types (for example, Employee WorksFor Department).
  - An Association can be 1-to-1 or 1-to-many, uni-directional or bi-directional.
  - A **Navigation Property** is property of an Entity Type bound to a specific association, which can be used to refer to associations of an entity.

Using OData,

- the physical data structure of a remote data server is its own business.
- All that matters to a client is that data server returns a logical data model in reply to a request saying "get meta data".
- The client can then proceed to invoke create, read, update and delete operations on entities in that data model.

Business data model

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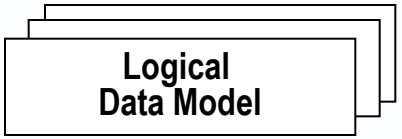
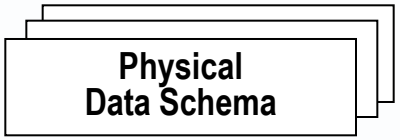
Conceptual	**Business Data Model** ▶ A conceptual data model that defines entities a business wants to remember, regardless of computing
Logical	
Physical	
Real	

TOGAF: Conceptual Data Diagram (aka business data model)

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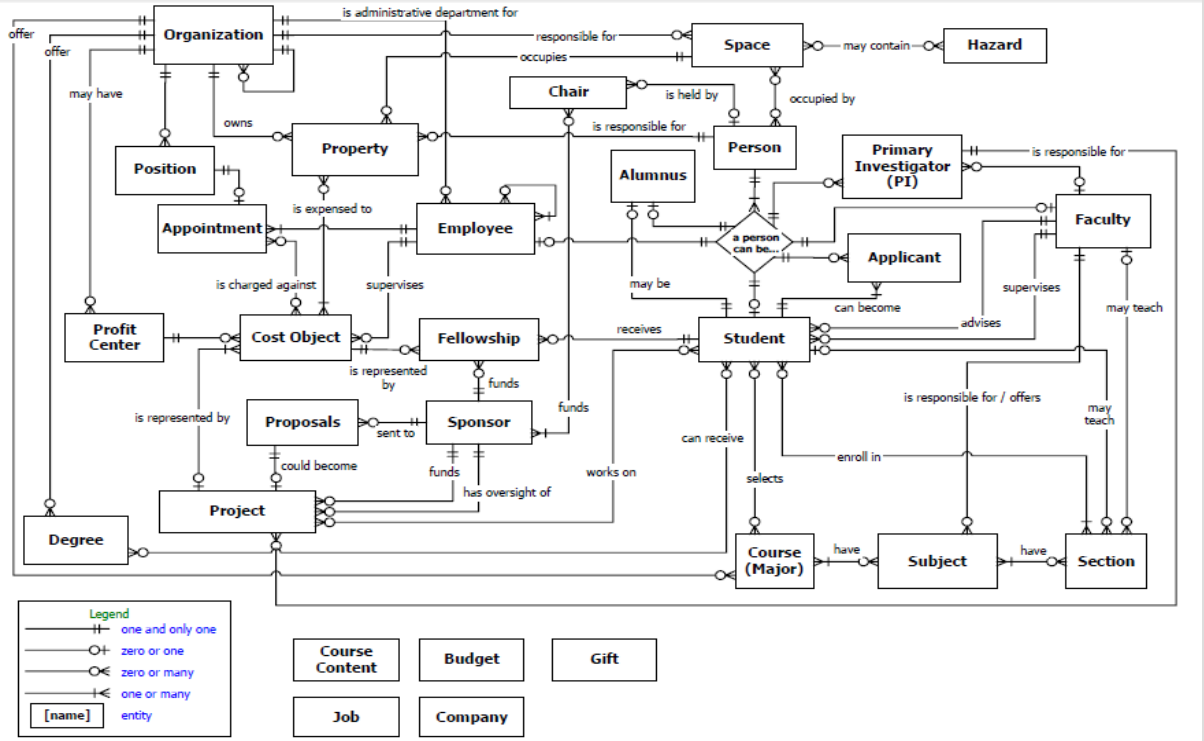
- to depict the relationships between critical data entities within the enterprise.
- developed to address the concerns of business stakeholders.



Enterprise/Business/Conceptual Data Model (MIT)

Difficult to draw

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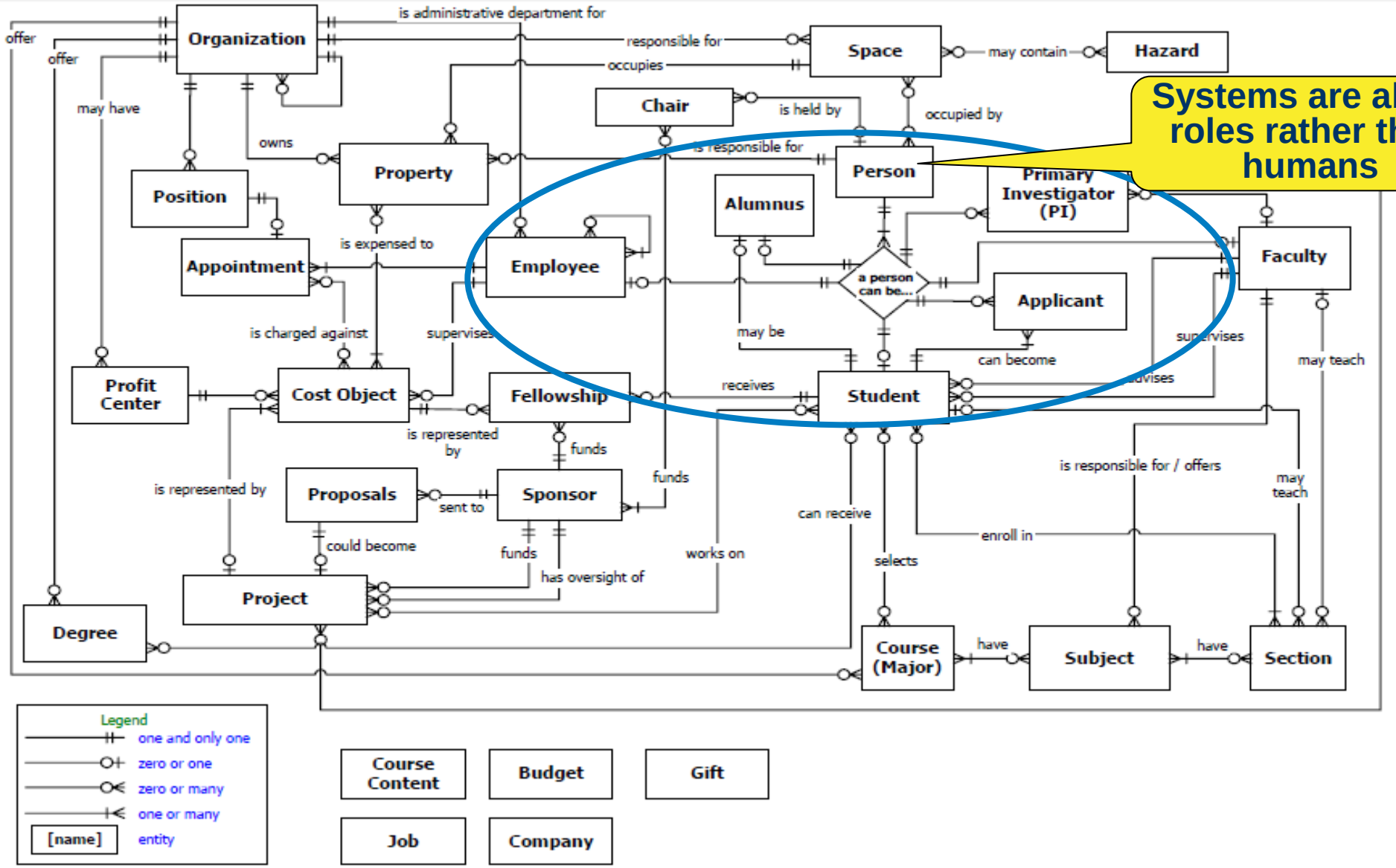

Systems are about roles rather than humans

Business Data Entity *Catalogues*

Easier and more practical

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- An enterprise might have scores of overlapping Logical Data Models
- Impractical build a Business Data Model with relationships between the entities

- INSTEAD
- List important and common data entities and group them under headings
- To help people to consider and describe data in new systems as they arise

- Products
  - products, services
- Properties
  - maintained resources, offices, vehicles, assets
- Promotions
  - campaigns, adverts, mailings
- Processes
  - transactions, events, orders, payments
- Places
  - areas, invoicing and delivery addresses
- Pipes
  - routes, networks
- Parties and people
  - customers, suppliers, organisations, employees
- Points in time
  - calendar, dates, times
- Pounds and Pennies
  - accounts, budgets, currencies
- Papers
  - documents

Duplication of data entity storage: email from **Magic Software**

- “Dear graham,
- Today's business users are accessing data from more sources than ever before which increases potential duplicate records, outdated information and allows for simple mistakes to slip through the cracks.
- More and more organisations are realising the negative impact that inaccurate and duplicate records cause within daily operations, and the expense of having to eliminate and manage this data.
- Addressing duplicate records efficiently requires a clear strategy and the tools to carry this out, such as:
  1. Identifying all internal systems that may contain duplicate records within the organisation;
  2. Establish rules that define what a duplicate record is;
  3. Defining actions that occur for duplicate data;
  4. Listing all duplicate records based on the criteria;
  5. Building real-time or scheduled processes to eliminate duplicate records re-entering the systems.”

Data dissemination view/matrix

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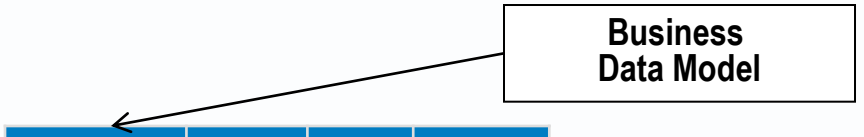
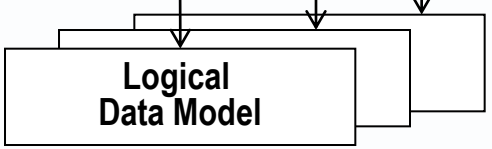
Conceptual



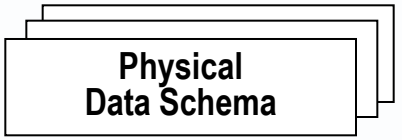
Data Entity	CRM	ERP	Billing
Customer	M	C	C
Sale	M(1)	C	M(2)
Invoice			M

- Data dissemination view/matrix

Logical



Physical



Real

TOGAF: Data Dissemination Diagram

- to show the relationship between data entity, business service, and application components.
- shows how the logical entities are to be physically realized by application components
- allows effective sizing to be carried out and the IT footprint to be refined.
- can indicate the business criticality of application components
- may show **data replication and application ownership** of the master reference for data.
- can show two copies and **the master-copy relationship between them.**

AM: Data Dissemination diagram: illustration

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- Tabulate data entities against data components (sources / stores)
- Define which data component is the master for each entity.

Application database / Data entity	CRM database	ERP database	Billing database	Data warehouse
Customer	Master	Copy	Copy	Copy
Sale	Master (1)	Copy	Master (2)	Copy
Invoice			Master	Copy

(1) until Order Closed
(2) after Order Closed.

- Note that attributes of an entity may be mastered in different data stores.
- Gaps (columns and rows with no entries) may indicate where further analysis is needed.

Data store models

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Conceptual	**Business Data Model** Data dissemination view/matrix
Logical	**Logical Data Model**
Physical	**Physical Data Schema**
Real	**Data Store**

Aside: More data model layers?

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- Eskil Swende has related Data Models to the Zachman Framework

Question / Abstraction	What	How	Where	Who	When	Why
1 Identification						
2 Definition	Overall BDM					
3 Representation	Detailed BDMs					
4 Specification	LDMs					
5 Configuration	PDMs					
6 Instantiation	Data stores					

Data flows – data in motion

- Businesses have to move information from one place to another, between business actors and data stores.
- Data architects are concerned with the capture and transport of information in data structures.
- Concerns include:
  - The sources, destinations and contents of data flows
  - Physical data flow forms
  - Data flow format standards
  - Semantic interoperability

Data flow models

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Conceptual	Defines the ideal or common types for data items in data flows	**Canonical Data Model**
Logical	The proper form to define the logical structure of a data flow is a regular expression	**Data Flow Structure**
Physical	A data flow's content can be defined in various forms	**CSV, JSON, XML**
Real	At the bottom-level of a communication stack is the physical medium wires, Microwaves, Sound waves	**Data Flow**

Data qualities

- Meta data = data about data

- Data quality concerns include
  - Data types
  - Data standards
  - Data confidentiality, integrity and availability (CIA)
  - Data owners and stewards