Using Entity-Relationship Model
Intro to the Relational Model

Announcements

Project 1

- Select a team; Part 1 Step 1 before meeting staff
- Useful to read the all parts (rest up "soon")

Waiting list:

ER Definition Review

Entity: App "object" distinguishable from other objects

Attribute: Information that describes the entity

Attribute *domain*: Range of permissible values

e.g. integers 1-20, 20 character strings, timestamp

Entity Set: Collection of entities with same attributes

Relationship: Association between entities

Relationship Set: Collection of similar relationships

Keys

Minimal set of attributes that uniquely identify an entity

May be multiple candidate keys

- e.g. User: both uid and email may be unique

May involve multiple attributes

- e.g. Class identified by both number and section

Primary key: designated unique identifier

Most entities have a key (except weak entities)

Diagram: Underlined

Weak Entity

Entity without a key: attributes are not unique

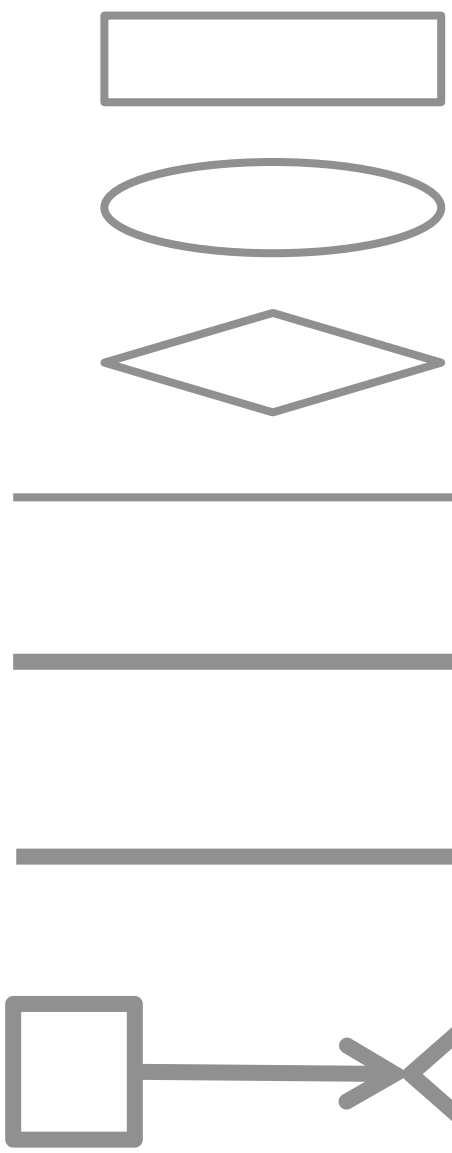
Identifying relationship distinguishes them

- e.g. Wall Post: User who posted it
- e.g. Song: Album where first released

Partial key: attributes that identify the weak entity, for a given owning entity

- e.g. Wall Post: Timestamp attribute
- e.g. Song: Title Name attribute

Diagram: Dashed underline



Entity

Attribute

Relationship

At most one (key constraint)

At least one (participation con.)

Exactly one

Weak Entity

Class Hierarchy

Aggregation

Using the ER Model

Explore design choices for a concept

Entity or Attribute?

Entity or Relationship?

Binary or Ternary relationship?

Aggregation or Ternary relationship?

Entity or Attribute?

Is address an attribute of Users or an entity connected to Users by a relationship?

>1 instance of attribute: must be an entity

e.g. home and work addresses?

Attribute has structure, use entity:

e.g., search for users by city, state, or zip

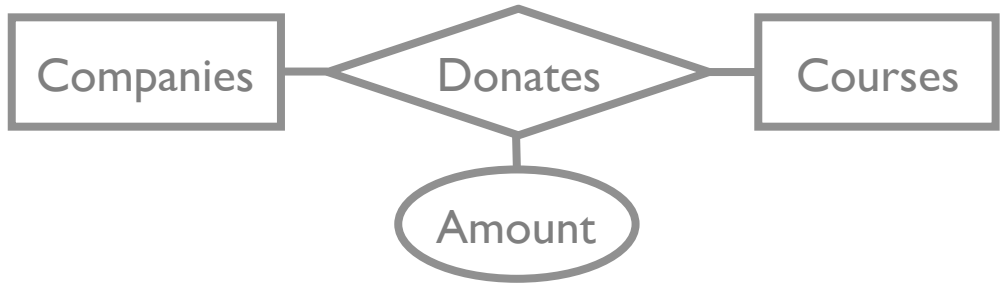
alternative: use multiple attributes? DRY?

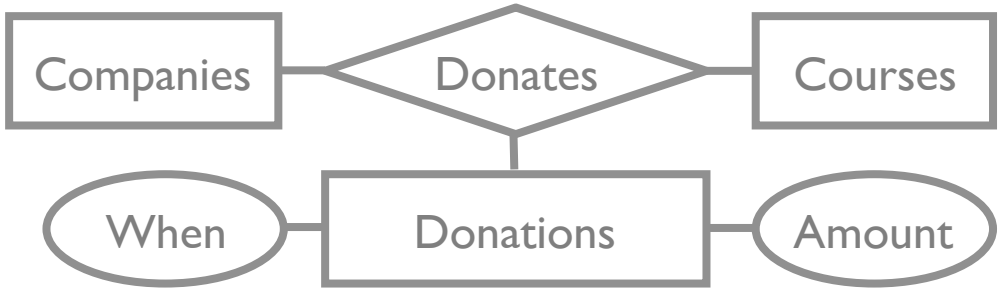
Entity or Attribute?

>1 instance of relationship attribute: Use entity

A company can't donate multiple amounts (top fig)

Use ternary relationship (bottom fig)



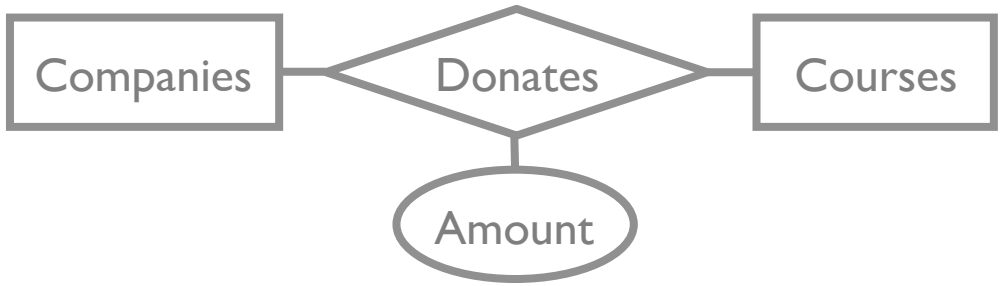


Entity or Relationship?

OK if company donates to courses individually

What if company donates once for a set of courses?

- Redundancy of *amount*, need to remember to update every one
- Misleading implies *amount* tied to *each* donation individually



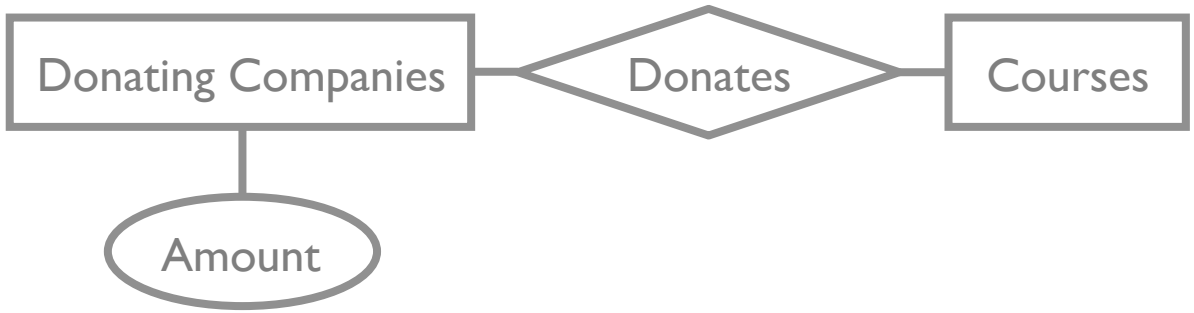
Company	Course	Amount
Amazon	4111	2000
Amazon	4112	2000
Amazon	5111	2000

These amounts are logically the same (redundant)!

Entity or Relationship?

Add "Donating Company," move amount to attribute

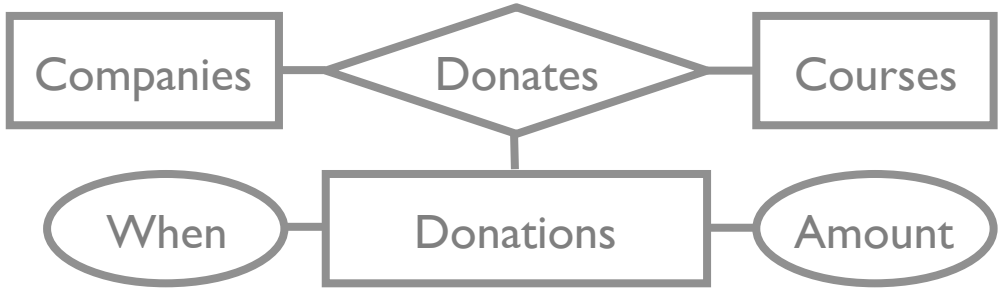
Need ISA with Company: companies without donations



Entity or Relationship?

If company donates once to school for data related courses.

Refactor amount into an entity

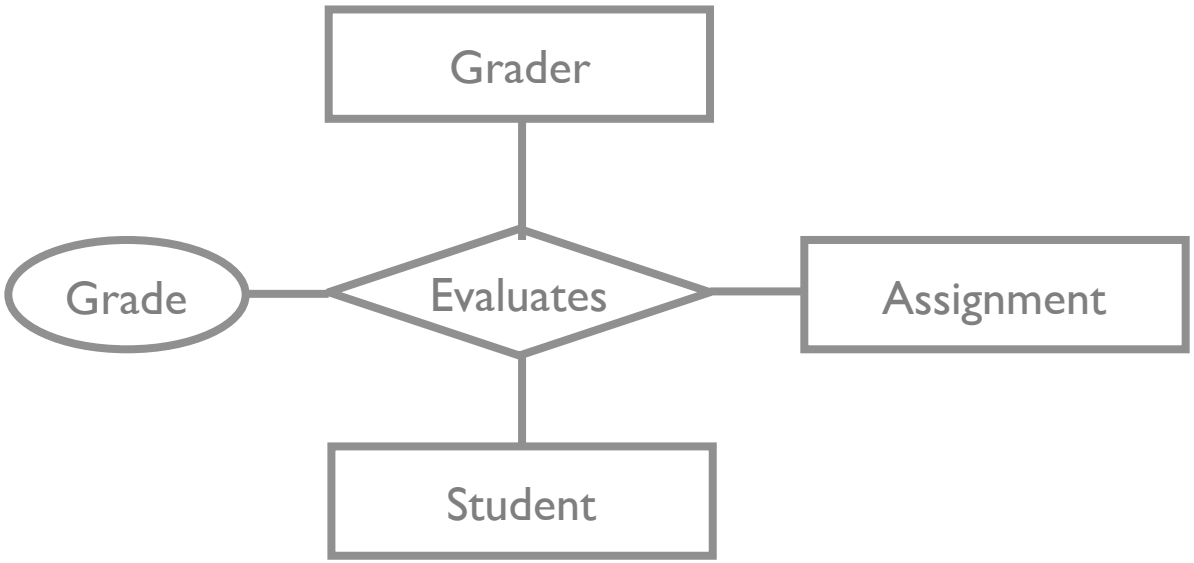


Company	Course	Donation
Amazon	4111	1
Amazon	4112	1
Amazon	5111	1

Donation	When	Amount
1	Today	2000

Binary or Ternary Relationship?

What if assignments have at most one grader?

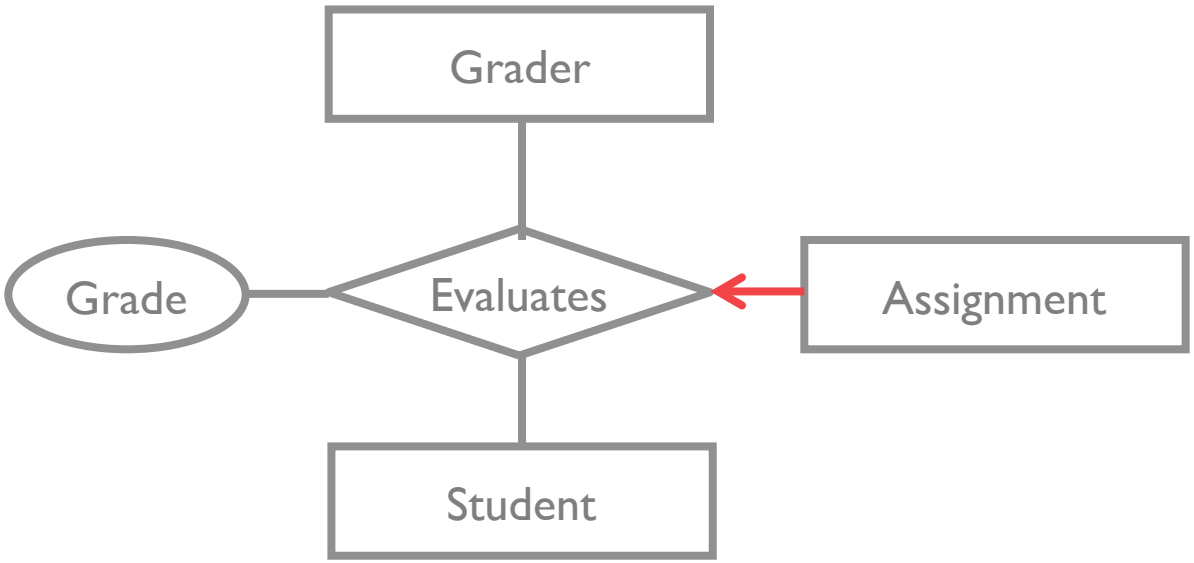


Binary or Ternary Relationship?

What if assignments have at most one grader?

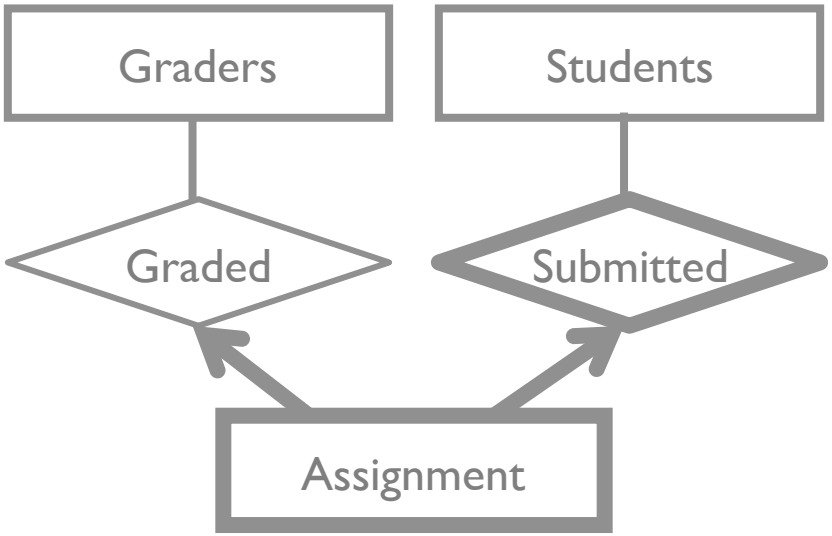
Only one student can complete HW0!

Actually two separate relationships



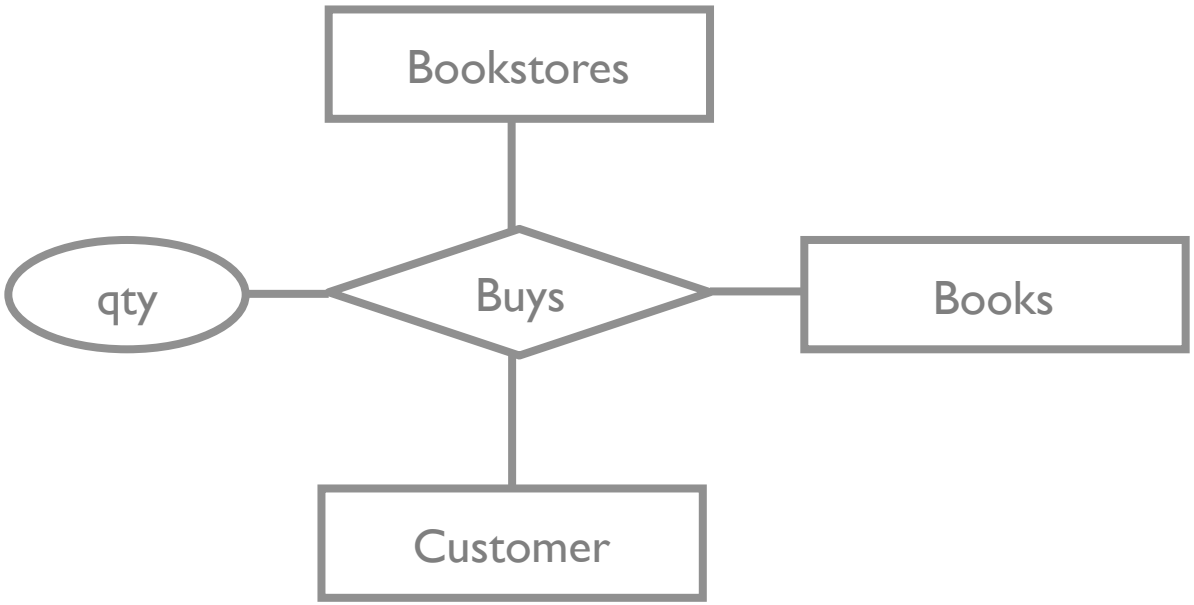
Binary or Ternary Relationship?

Binary relationships allows additional constraints



Binary or Ternary Relationship?

Sometimes have true ternary relationship that is defined by all three entities.



Summary

Requirements

what are you going to build?

Conceptual Database Design

high-level description

(Today) ER Modeling

Logical Design

formal database schema

Schema Refinement:

fix potential problems, normalization

Physical Database Design

use sample of queries to optimize for speed/storage

Summary

ER design is subjective based on usage and needs

- Today we saw multiple ways to model same idea

ER design is not complete/perfect

- Doesn't capture semantics (what does "instructor" *mean?)*
- Doesn't capture processes/state machines

ER design is a useful way of thought

Real World?

Visual, high-level tool to explore and explain

Many variants

Used, but not often

Important ideas:

Go from high-level to details

Relationships: Related data is very powerful

Constraints: many-to-many, one-to-many

The Relational Model

Neil Conway @neil_conway · 20m

Dear twitter folks, what's the most interesting paper you read recently?

RETWEET
1

FAVORITE
1


4:44 PM - 14 Sep 2015 · Details

Reply to @neil_conway

Saurabh Sharan @saurabhsharan · 15m

@neil_conway "What Goes Around Comes Around" by Stonebraker & Hellerstein - good overview of different data models mitpress.mit.edu/sites/default/…

1

Background

- Most widely used data model in the world

- Legacy Models
- IMS hierarchical
- CODASYL network

- "NoSQL": various recent flexible models

Key Principles

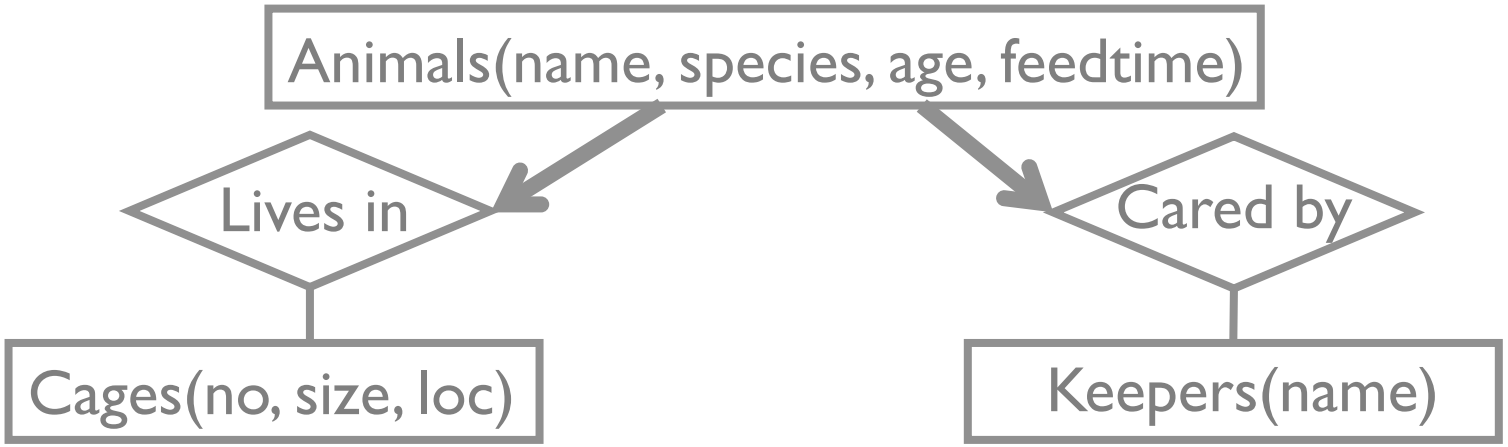
- Data redundancy (or how to avoid it)
- Physical data independence
  - programs don't worry about physical structure
- Logical data independence
  - logical structure can change and legacy programs can continue to run
- High level languages

Historical Context (not on test)

- Hierarchical model (IMS)
- Network model (CODASYL)
- Relational model (SQL/QUEL)

70s

80-90s



T/F: empty cage permitted? Animal with two keepers?

Hierarchical Model (IMS, circa 1968)

- IBM Information Management System:
- **Apollo program for BOM Saturn V rocket**
- Segment types (objects / entity sets) with fields (attribs)
- Segment instances (records)
- Segment types form a tree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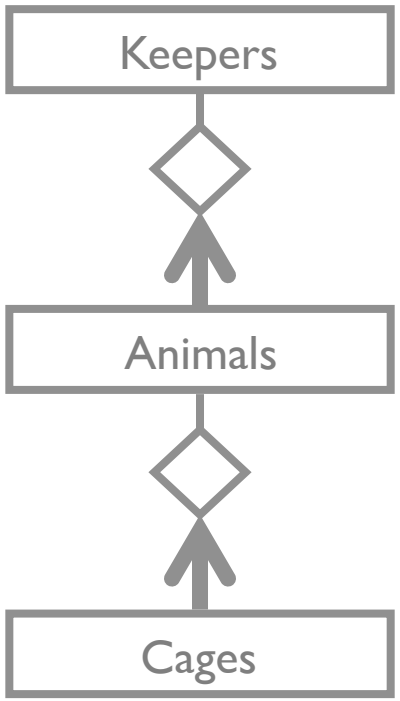
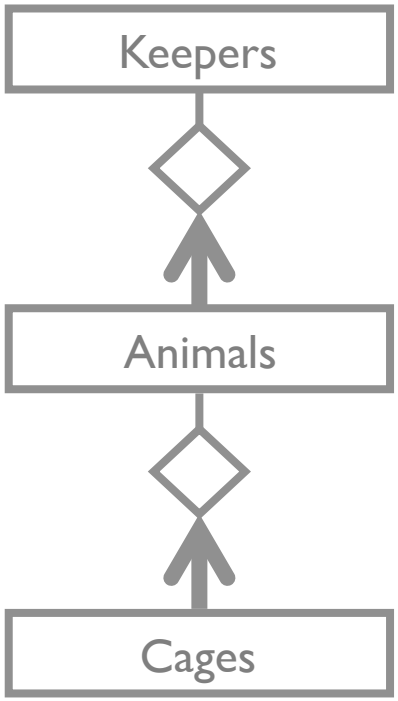
Hierarchical Model (IMS, circa 1968)

- IBM Information Management System:
- **Apollo program for BOM Saturn V rocket**
- Segment types (entity sets) with fields (attributes)
- Segment instances (entities)
- Segment types form a tree:
- Sub-records must have "parent"



Hierarchical Model (IMS, circa 1968)

- Jane (Keeper) (HSK 1)
- Bob, iguana, … (2)
- 1, 100ft^2, … (3)
- Joe, student, … (4)
- 1, 100ft^2, … (5)
- …



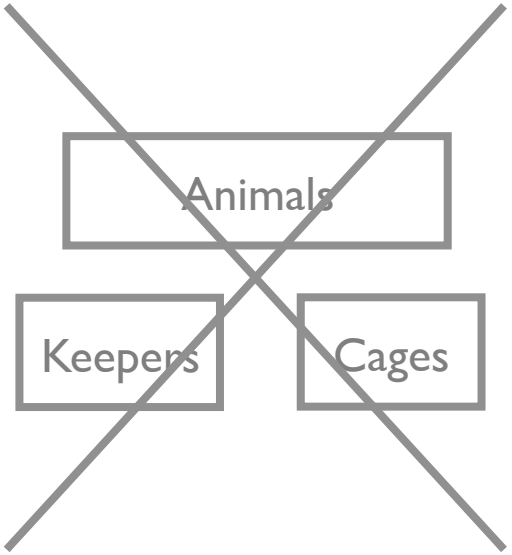
What's repeated?

Inconsistencies possible, lack of protections

Hierarchical Model Limitations

Repeats cage data
(>1 animals in a cage)

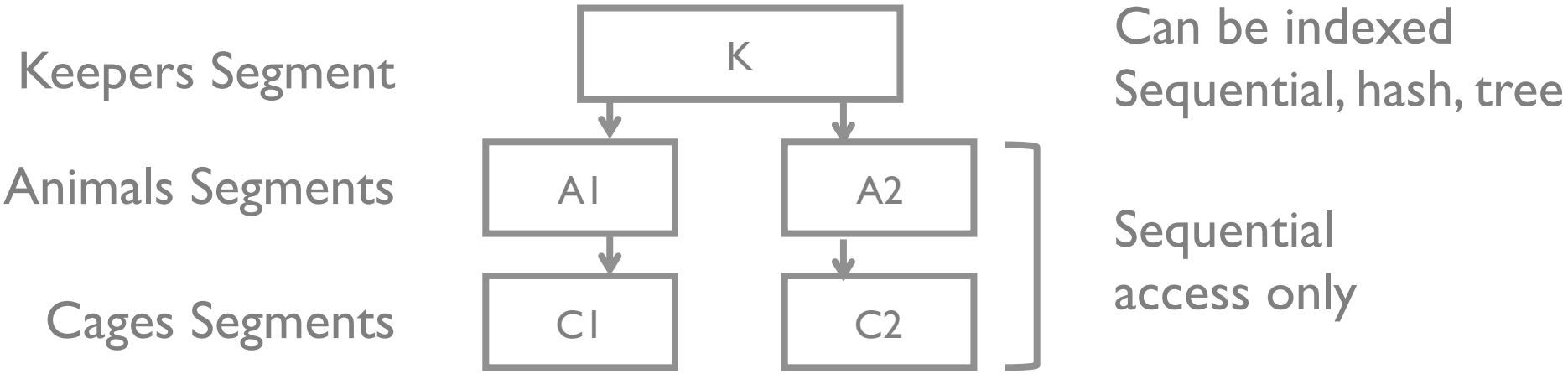
Repeats keeper data
(>1 animals/keeper)



Disallowed

Physical Storage

- Stored hierarchically
- Only root segment can be indexed
- Other segments only accessed sequentially



Hierarchical Querying: DL-1

- *Navigational Querying* through a tree structure
- Core operations
- GX(seg, pred) general form, takes seg type and a predicate

  - Get Unique (GU) start at parent (root) segment
  - Get Next (GN) next record in HSK order in database
  - Get Next in Parent (GNP) next in HSK order until end of subtree

Fetch cages that Eugene entered

```
GU(Keeper, name = Eugene)
Until no more records
    cage = GNP(Cage)
    print cage.no
```

Problems

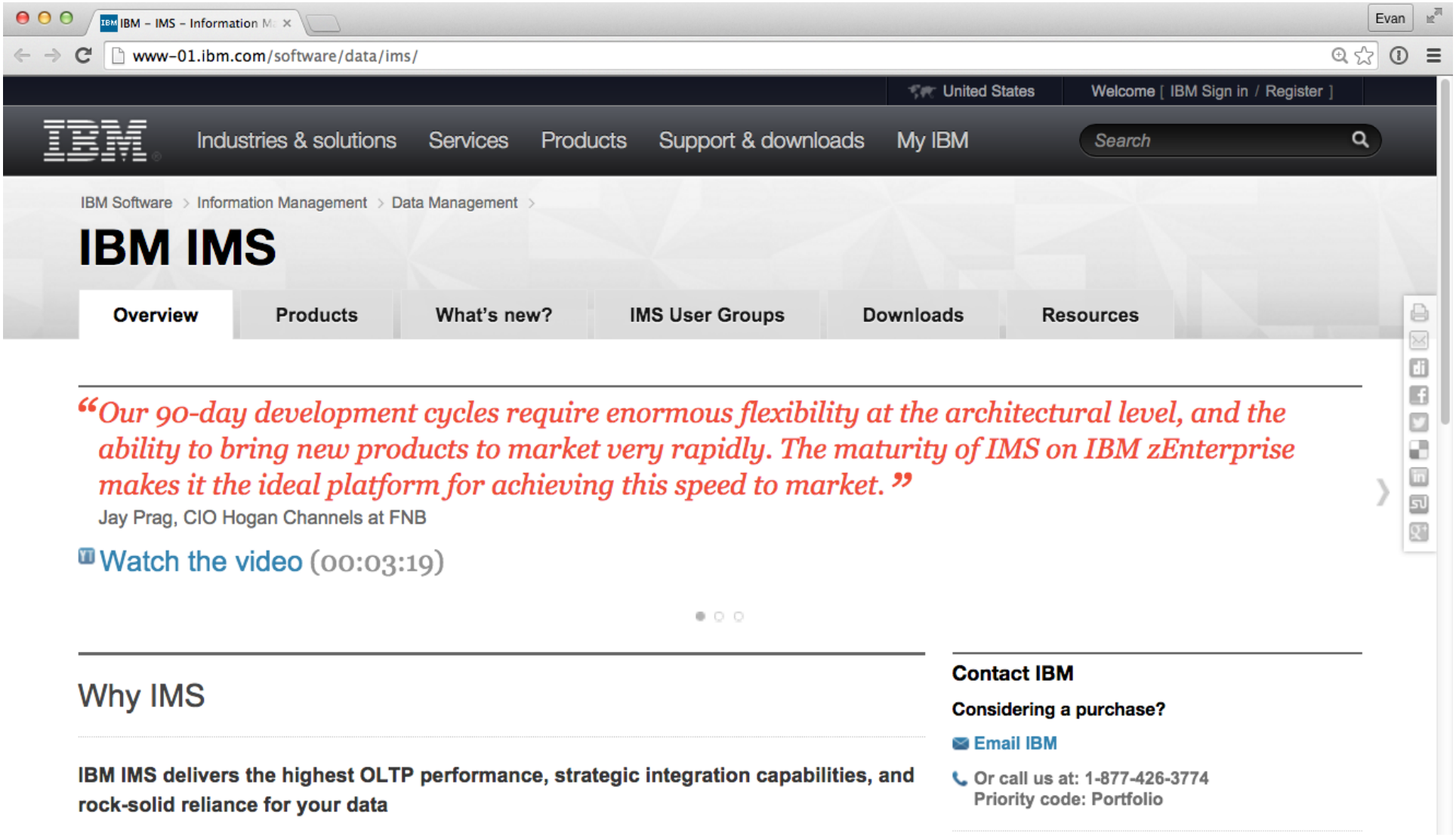
- Duplicates data
- Low level programming interface
- Almost no physical data independence
  - Change root from tree to hash index causes programs with GN on root to *fail*
  - Inserts into sequential root structures disallowed
- Lacks logical data independence
  - Changing schema requires changing program

- Violates many desirable properties
  - of a proper DBMS

More Problems

- Schema changes require program changes because pointers after GN calls now different

- In reality, schemas change all the time
  - Keepers now responsible for a whole cage
  - Hummingbirds require multiple feedings
  - Merge with another zoo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What is IMS?

- IMS = **I**nformation **M**anagement **S**ystem

- IMS is two products:
  - IMS Transaction Manager – IMS TM
    - Previously called IMS DC (Data Communications) or IMS TP (teleprocessing)
  - IMS Database Manager – IMS DB
    - Hierarchical Database Management System

- All products run on the mainframe (z/OS) only

- Proven track record of 46 years!!!

- “Watts joined IBM in 1956 and worked at IBM's Silicon Valley development labs until his death on April 4, 2009.[2] *He had continuously worked on IMS since the 1960s.*”

- Wikipedia: https://en.wikipedia.org/wiki/IBM_Information_Management_System

IMS runs the world's most critical workloads

16 petabytes of production data managed by IMS

$3.0 trillion ($US) per day is transferred through IMS.....by one customer

300+ million users served every day

500 million accounts.....for one customer

Plus ...


Major US Insurance Company
Handelsbanken
BNP PARIBAS
CREDIT SUISSE
GAD
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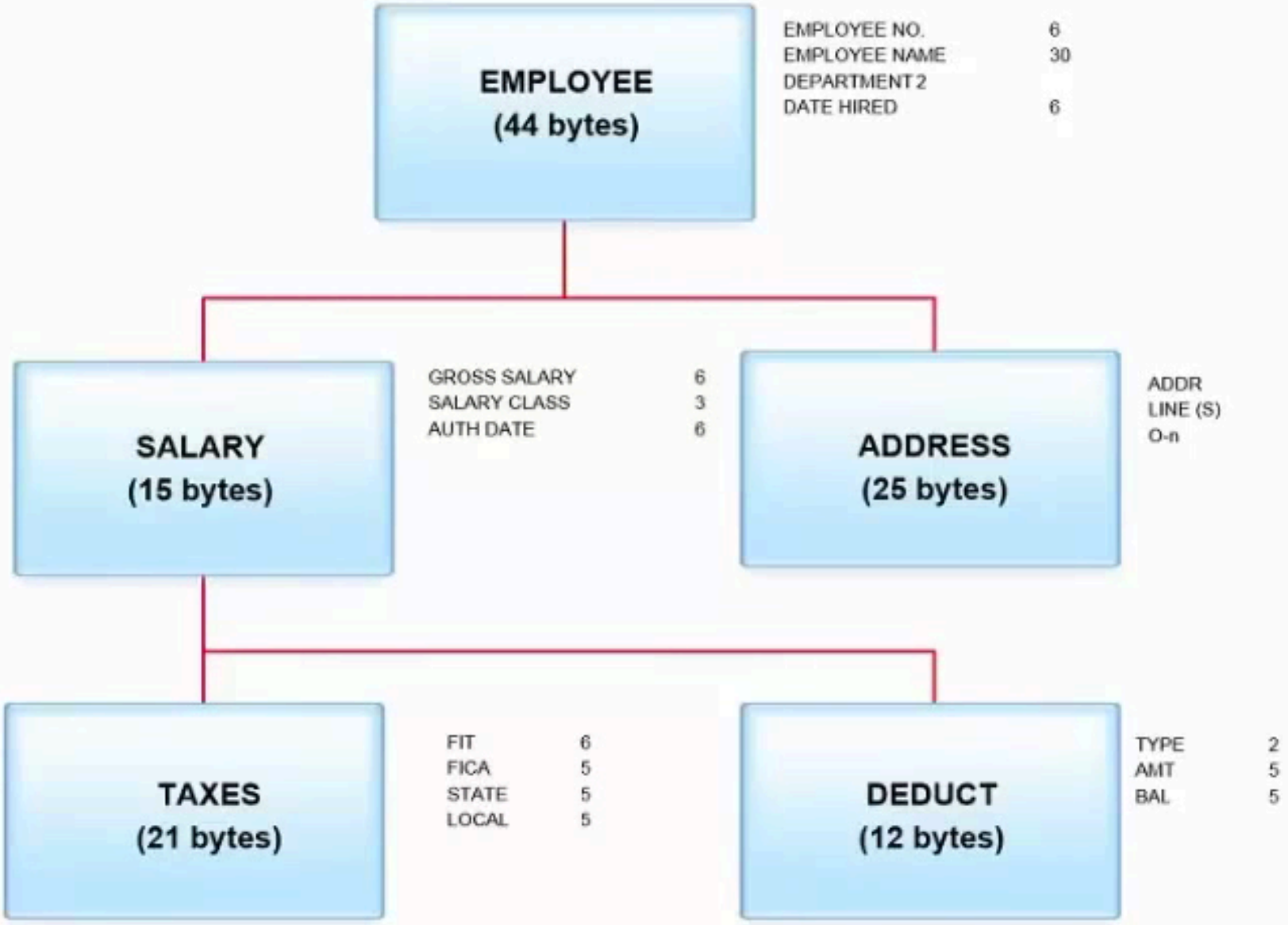
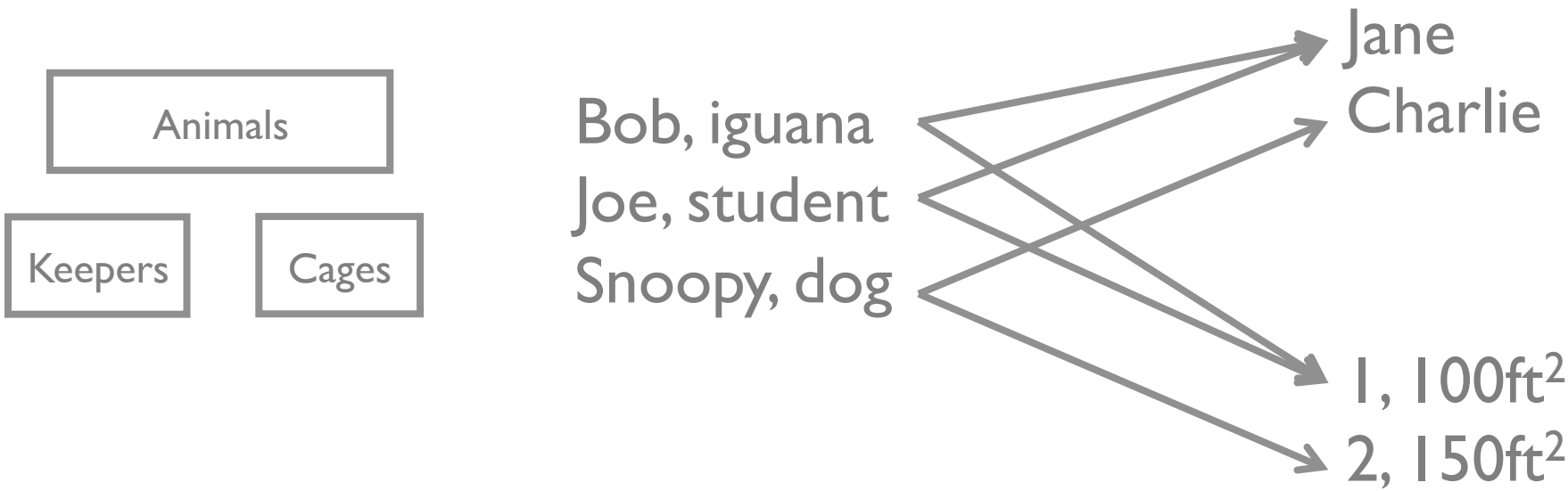
"la Caixa"
WELLPOINT

IMS DB: Hierarchical DBMS



Network Models (CODASYL, 1969)

- Abstraction
  - Types of Records
  - Connected by named sets (one to many relationships)
  - Modeled as a graph



Network Models: Queries

- Queries are programs that follow pointers (IMS style)

```
Find Keeper (name = 'Eugene')
until no more
   Find next Animal in cares_for
   Find Cage in lives_in
   Get current record
```

Very Smart people (Charles Bachman, '73 Turing Award) strongly defended this model but…

Network Models: Problems

- Very complex due to navigational programming
- (not for mere mortals!)
- Still no physical nor logical data independence
- Implementations were limiting
- must load all data at once

- Trades off increased programmer pain for modeling non-hierarchical data

Oracle CODASYL DBMS

Enhancements to Oracle CODASYL DBMS continue to focus on high availability, performance, and very large database support the very features that have given CODASYL DBMS a reputation for stability and reliability.

Oracle CODASYL DBMS

Oracle CODASYL DBMS is a multi-user, general purpose database management system that runs on the OpenVMS operating system. DBMS can be used to access and administer databases ranging in complexity from simple hierarchies to co mplex networks with multi-level relationships. It supports full concurrent access in a multi-user environment without compromising the integrity and security of the user's databases. The majority of DBMS installations occur through application providers using DBMS as the underlying database.

Oracle CODASYL DBMS is designed for users working in a structured application environment. The users are programmers, an alysts, designers, or administrators who use conventional planning and coding techniques to design, create, and maintain long-term applications for corporate use. The characteristics include high availability and throughput coupled with system manage ment features that minimize downtime. Examples are large-scale applications such as manufacturing and shop floor systems that require a stable environment not subject to change.

DBMS7: Strategic Enhancements

Strategic enhancements for Release 7 of DBMS included very large memory addressing support. Shared record cache allows DBMS to use as much physical memory as a computer system can support, so that frequently accessed records can be stored in memory to reduce disk I/O. Th e advantages include:

Relational Model (1970)

- Ted Codd, 1970
- Reaction to CODASYL

- Key properties

1. simple representation
2. set oriented model
3. no physical data model needed

A Relational Model of Data for Large Shared Data Banks

E. F. Codd
IBM Research Laboratory, San Jose, California

Future users of large data banks must be protected from having to know how the data is organized in the machine (the internal representation). A prompting service which supplies such information is not a satisfactory solution. Activities of users at terminals and most application programs should remain unaffected when the internal representation of data is changed and even when some aspects of the external representation are changed. Changes in data representation will often be needed as a result of changes in query, update, and report traffic and natural growth in the types of stored information.

Existing noninferential, formatted data systems provide users with tree-structured files or slightly more general network models of the data. In Section 1, inadequacies of these models

Optional Reading

- What Goes Around Comes Around, Stonebraker and Hellerstein

- Overview of the history of different data models