Informatics 1: Data & Analysis

Lecture 4: From ER Diagrams to Relational Models

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Semester 2 Week 2

THE UNIVERSITY *of* EDINBURGH

Lecture Plan

Data Representation

This first course section starts by presenting two common data representation models.

- The *entity-relationship (ER)* model
- The *relational* model

Data Manipulation

This is followed by some methods for manipulating data in the relational model and using it to extract information.

- *Relational algebra*
- The *tuple-relational calculus*
- The query language *SQL*

Homework !

The tutorial worksheet was posted to the course website earlier this week. Download it, read the instructions, follow them.

There are six questions on the sheet, progressively designing and then drawing an Entity-Relationship model for part of a database system.

There is flexibility in how you design the model, and you might come up with alternative answers.

Write or print out your work and bring it along to the tutorial: you will need to show it to your tutor, and possibly exchange with other students.

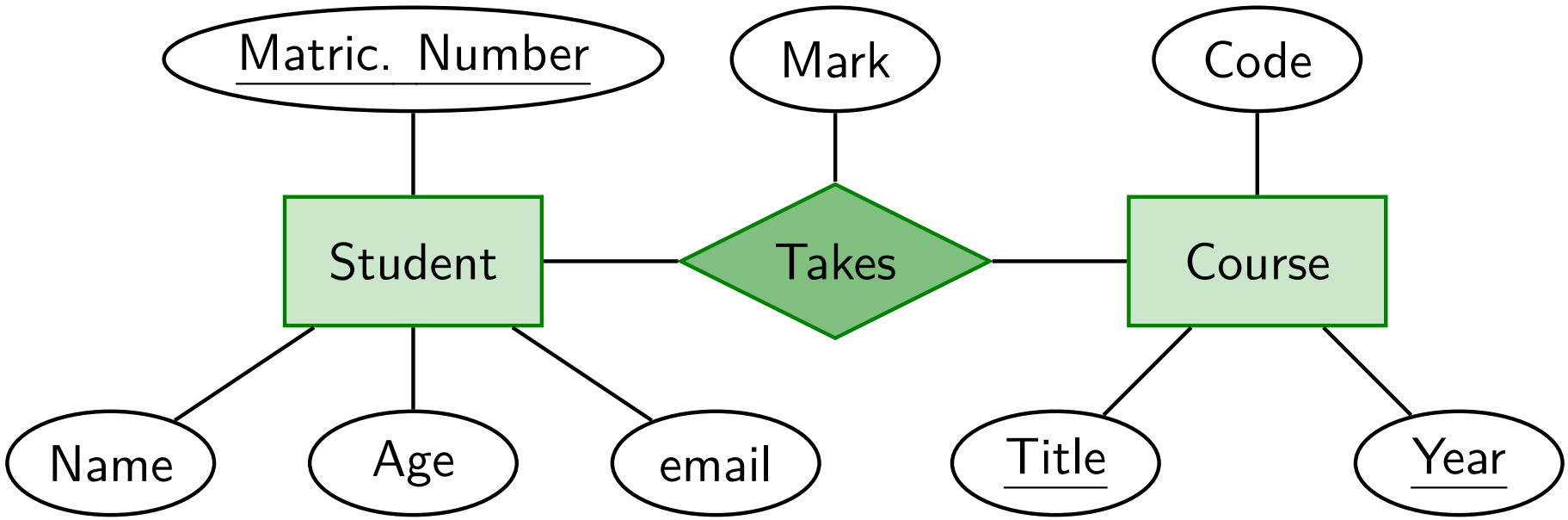
If you find parts difficult, or have questions about the exercise: ask on Piazza; go to InfBASE for help; bring your problem to the tutorials.

The worksheet also has example problems and solution notes.

The Story so Far

Entity-Relationship diagrams

- Entities: Rectangles
- Relationships: Diamonds linked to the entities
- Attributes: Ovals linked to entity or relationship
- Key constraints as arrows; total participation as thick lines
- Weak entities with their identifying relationship; Entity hierarchies



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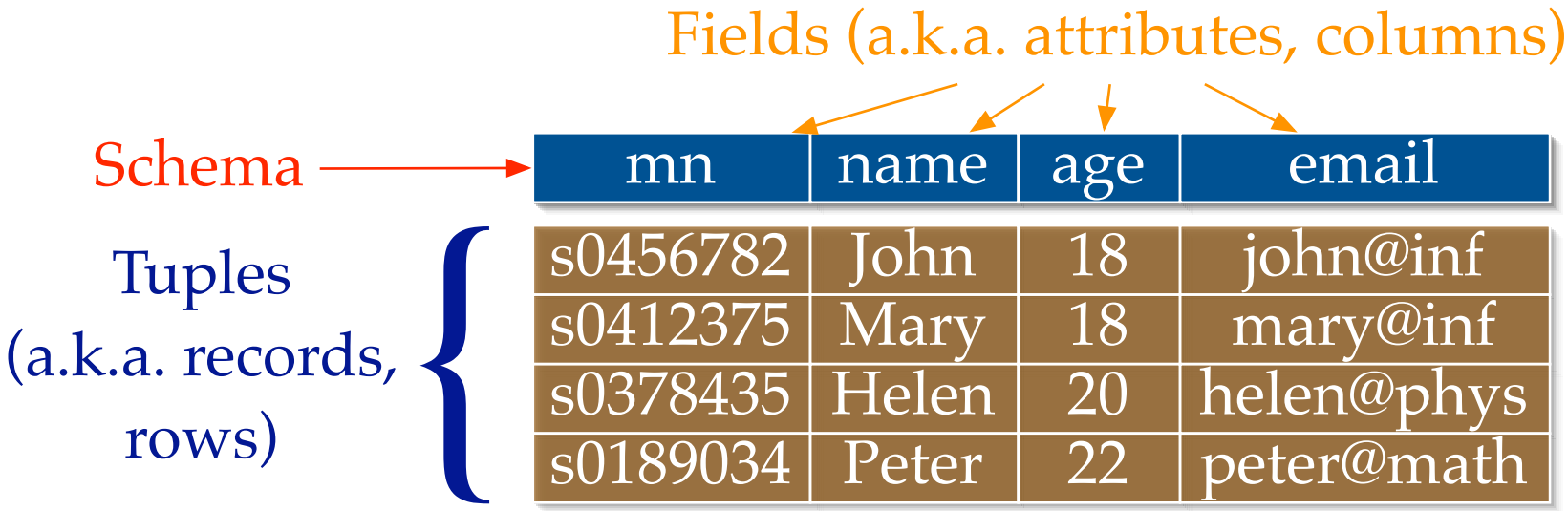
Relational models

- Relations: Tables matching schemas
- Schema: A set of field names and their domains
- Table: A set of tuples of values matching these fields
- Primary key: Chosen uniquely-valued field or set of fields
- Foreign key: Must be drawn from key values in another table

The Story so Far



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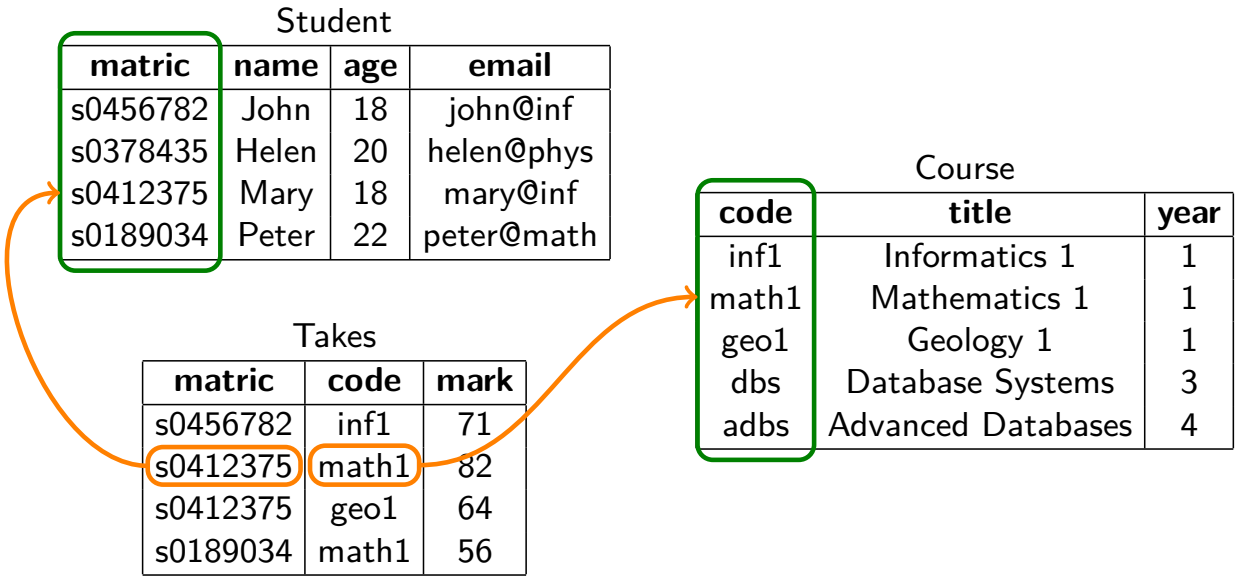

Student

matric	name	age	email
s0456782	John	18	john@inf
s0378435	Helen	20	helen@phys
s0412375	Mary	18	mary@inf
s0189034	Peter	22	peter@math

Takes

matric	code	mark
s0456782	inf1	71
s0412375	math1	82
s0412375	geo1	64
s0189034	math1	56

Course

code	title	year
inf1	Informatics 1	1
math1	Mathematics 1	1
geo1	Geology 1	1
dbs	Database Systems	3
adbs	Advanced Databases	4

Relational models

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- Schema: A set of field names and their domains
- Table: A set of tuples of values matching these fields
- Primary key: Chosen uniquely-valued field or set of fields
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The Story so Far

```
CREATE TABLE Takes (
    matric  VARCHAR(8),
    code    VARCHAR(20),
    mark    INTEGER,
    PRIMARY KEY (matric, code),
    FOREIGN KEY (matric) REFERENCES Student,
    FOREIGN KEY (code)   REFERENCES Course )
```

Relational models

- Relations: Tables matching schemas
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Aim and Scale

The University of Edinburgh has 33 115 matriculated students studying 9 163 different courses across 22 different schools in 764 buildings.

With a relational database we can ask, and answer, questions like:

- What are the names and email addresses of all students taking a first-year course taught by the School of Informatics?
- Which lectures have been scheduled for rooms which will be at greater than 90% of their seating capacity?

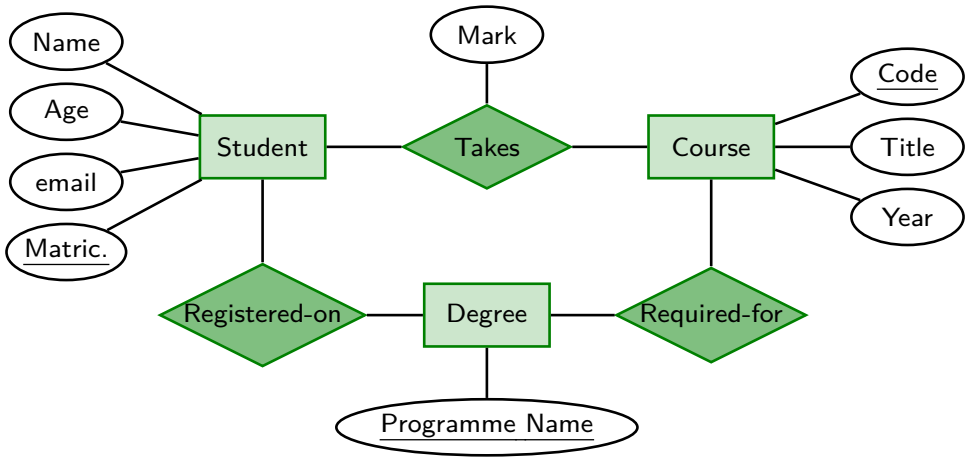
Many databases are much, much larger than this with much more complex queries. However, the aim is the same: how to go beyond answering a single query with a single program to a general system in which many queries can be expressed and answered efficiently.

Translating ER Diagrams to Relational Models

An ER diagram captures a conceptual model of the data to be managed in a database: what there is and how it is connected.

We can use this as a basis for a relational schema, as a step towards implementation in a working RDBMS.

This translation will be approximate: some constraints expressed in an ER diagram might not naturally fit into relational schemas.



CREATE TABLE Student a(...)

CREATE TABLE Takes (...)

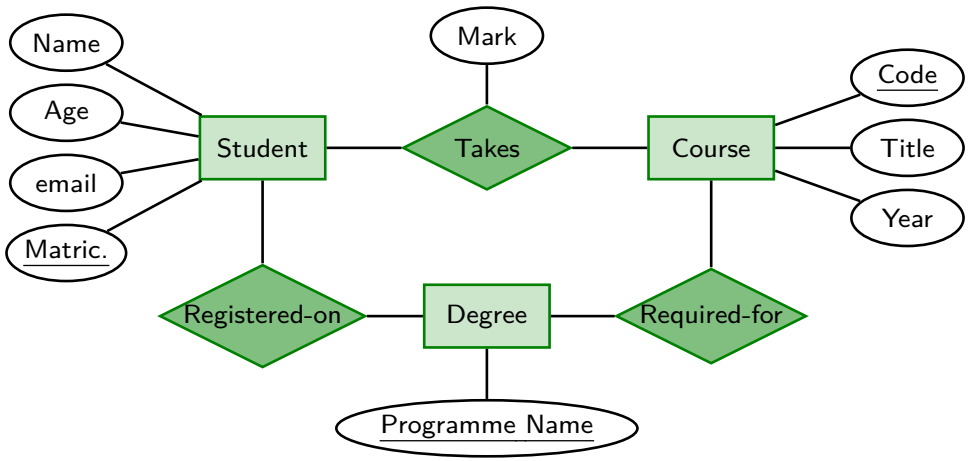
CREATE TABLE Course (...)

etc.

Translating ER Diagrams to Relational Models

There may be more than one possible translation: different alternatives lead to different implementations. These may be efficiency trade-offs, for which we might go back to the requirements to assess their relative impact.

It is possible to make these translations complete (work for any diagram) and automatic (in a push-button tool); but here we shall just consider a few examples illustrating some of the main ideas.



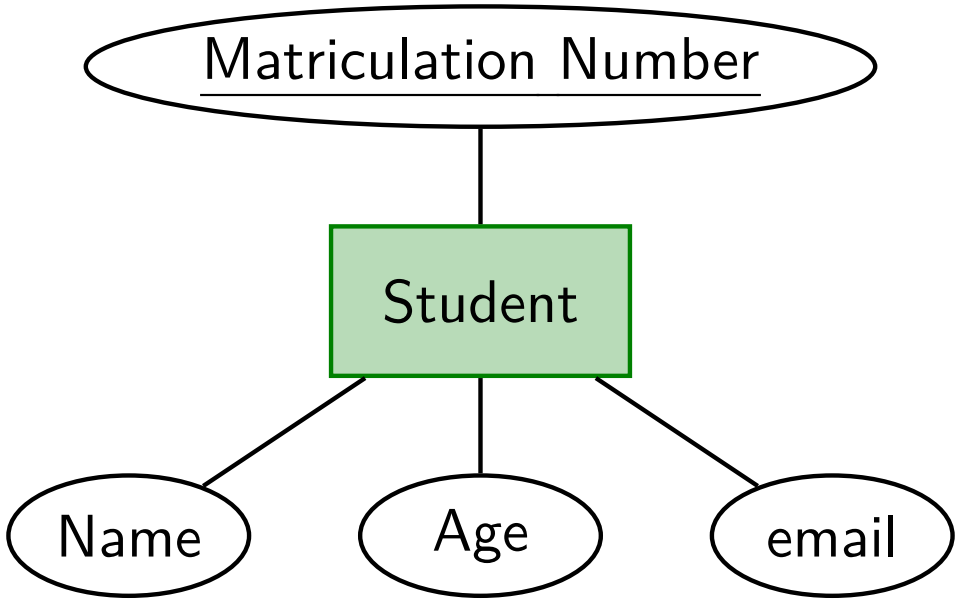
CREATE TABLE Student a(...)

CREATE TABLE Takes (...)

CREATE TABLE Course (...)

etc.

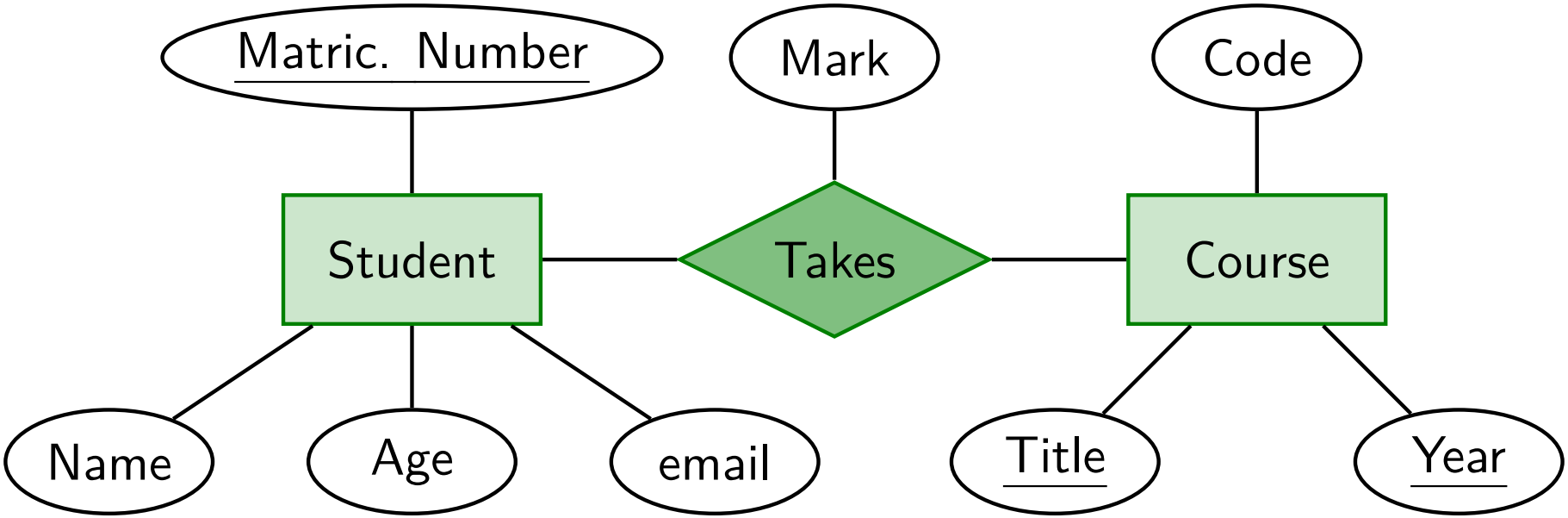
Mapping an Entity



- Create a table for the entity.
- Make each attribute of the entity a field of the table, with an appropriate type.
- Declare the field or fields which make up the primary key

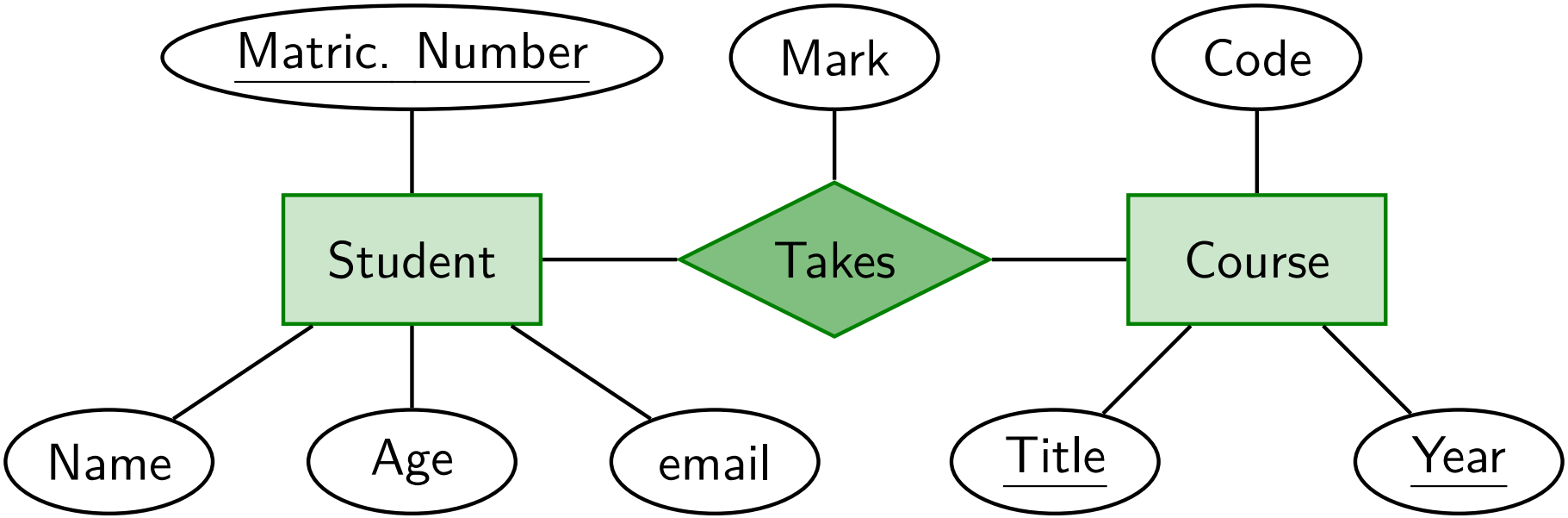
```
CREATE TABLE Student (
    matric   VARCHAR(8),
    name     VARCHAR(20),
    age      INTEGER,
    email    VARCHAR(25),
    PRIMARY KEY (matric) )
```

Mapping a Relationship



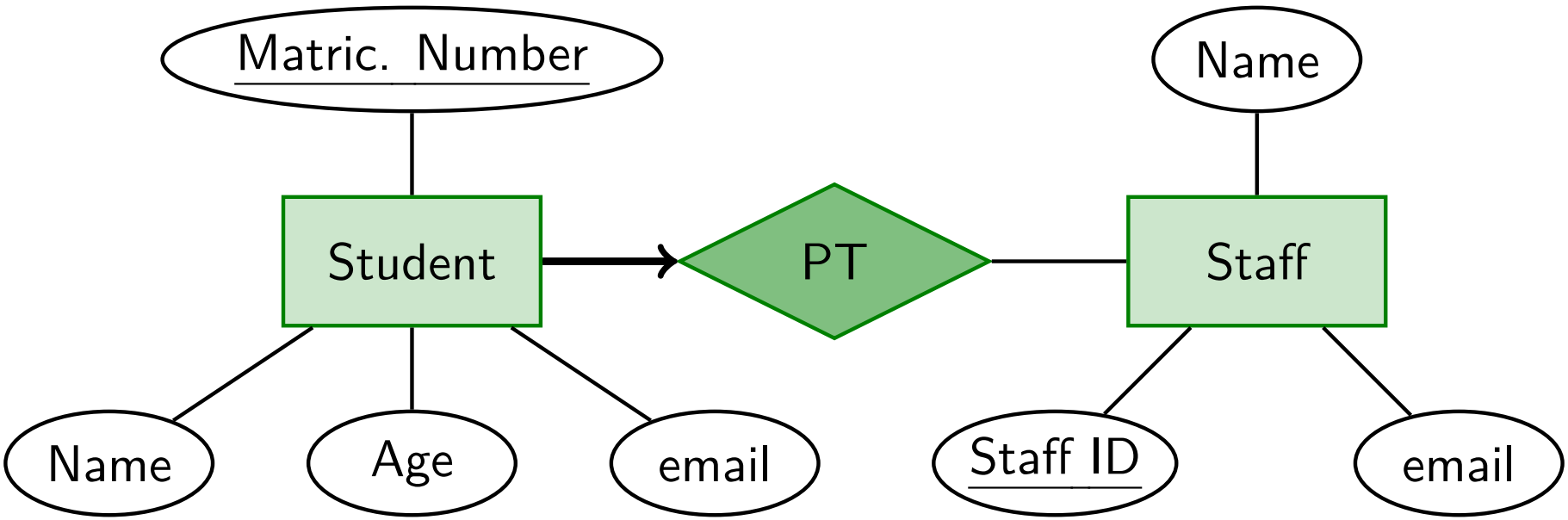
- Create tables for each entity, as before.
- Create a table for the relationship.
- Add all key attributes of all participating entities as fields.
- Add fields for each attribute of the relationship.
- Declare primary key using all key attributes from participating entities.
- Declare foreign key constraints for all these entity attributes.

Mapping a Relationship



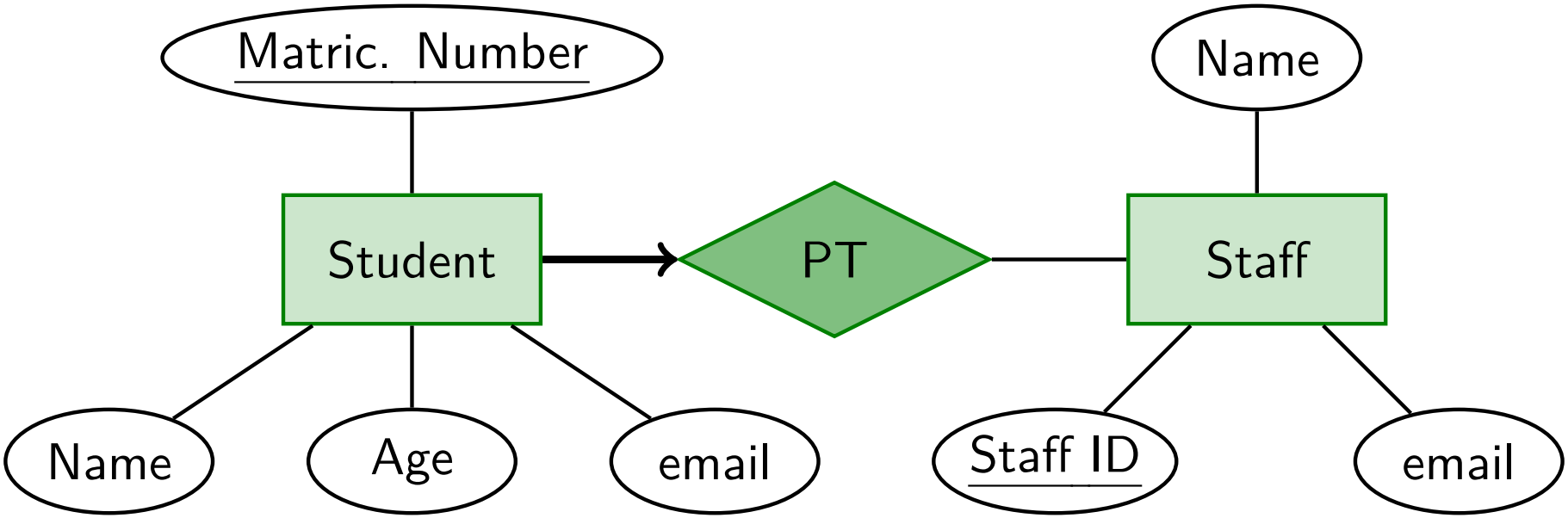

```
CREATE TABLE Takes (
    title   VARCHAR(25),    year  INTEGER,
    matric VARCHAR(8),      mark INTEGER,
    PRIMARY KEY (matric, title , year),
    FOREIGN KEY  (matric) REFERENCES Student,
    FOREIGN KEY  ( title , year) REFERENCES Course )
```

Mapping Key Constraints, Method 1



- Create tables for each entity, as before.
- Create a table for the relationship.
- Add all key attributes of all participating entities as fields.
- Add fields for each attribute of the relationship.
- Declare primary key using only key attributes of the source entity.
- Declare foreign key constraints on key attributes of all entities.

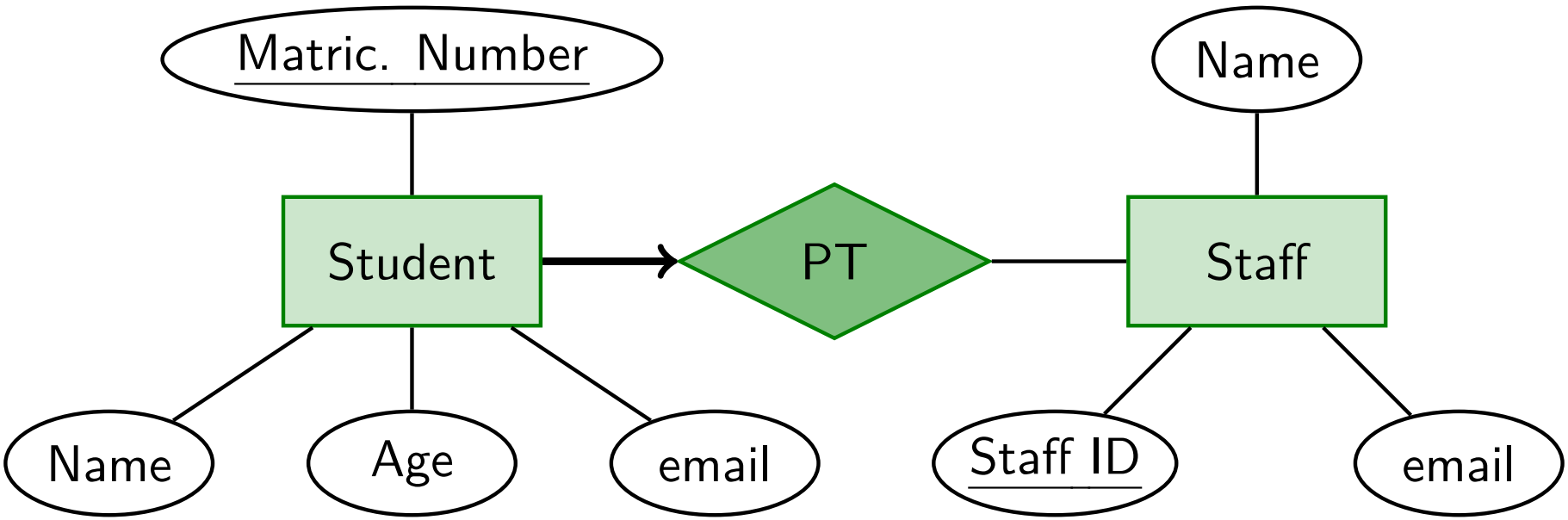
Mapping Key Constraints, Method 1




```
CREATE TABLE PersonalTutor (
    matric   VARCHAR(8),
    staff_id VARCHAR(8),
    PRIMARY KEY (matric),
    FOREIGN KEY (matric)   REFERENCES Student,
    FOREIGN KEY (staff_id) REFERENCES Staff )
```

This captures the key constraint, but not the participation constraint.

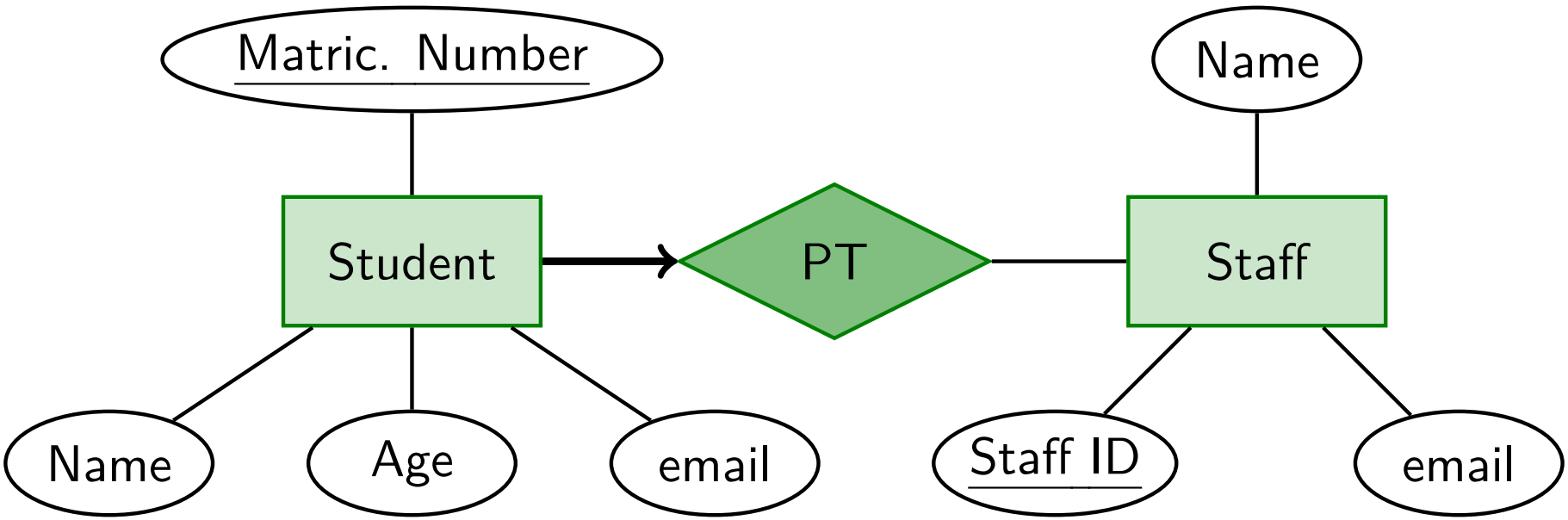
Mapping Key Constraints, Method 2



In fact, because the PT relationship is many-to-one, we don't need a whole table for the relation itself. However, this does slightly pollute the source entity table.

- Create a table for the source and target entities as usual.
- Add every key attribute of the target as a field in the source table.
- Declare these fields as foreign keys.

Mapping Key Constraints, Method 2




```
CREATE TABLE Student (
    matric  VARCHAR(8),     age    INTEGER,
    name    VARCHAR(20),    email  VARCHAR(25),
    pt      VARCHAR(8),
    PRIMARY KEY (matric),
    FOREIGN KEY  (pt) REFERENCES Staff(staff_id) )
```

This still does not capture total participation, but we are closer...

Null Values

A field in SQL can have the special value **NULL**.

NULL can mean many things: that a field is unknown, or missing, or unavailable; or that this field may not apply in certain situations.

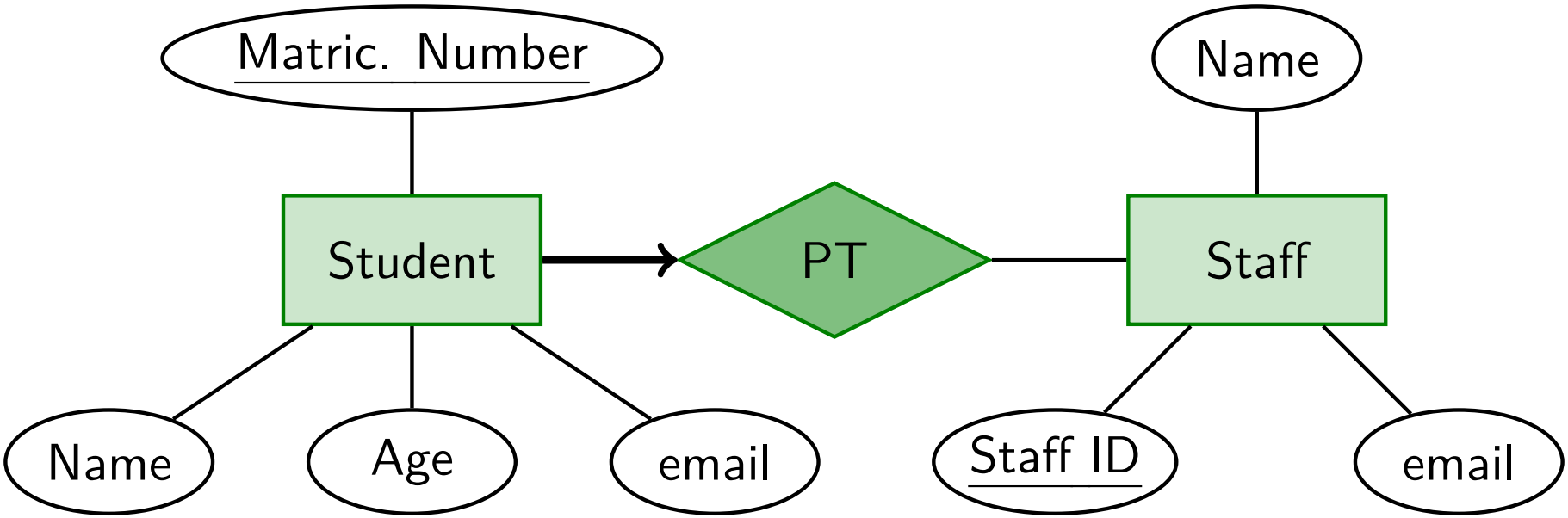
Some RDBMS forbid **NULL** from appearing in any field declared as a primary key.

Some of these may still allow **NULL** to appear in foreign key fields.

A schema can state that certain fields may not contain **NULL** using the **NOT NULL** declaration.

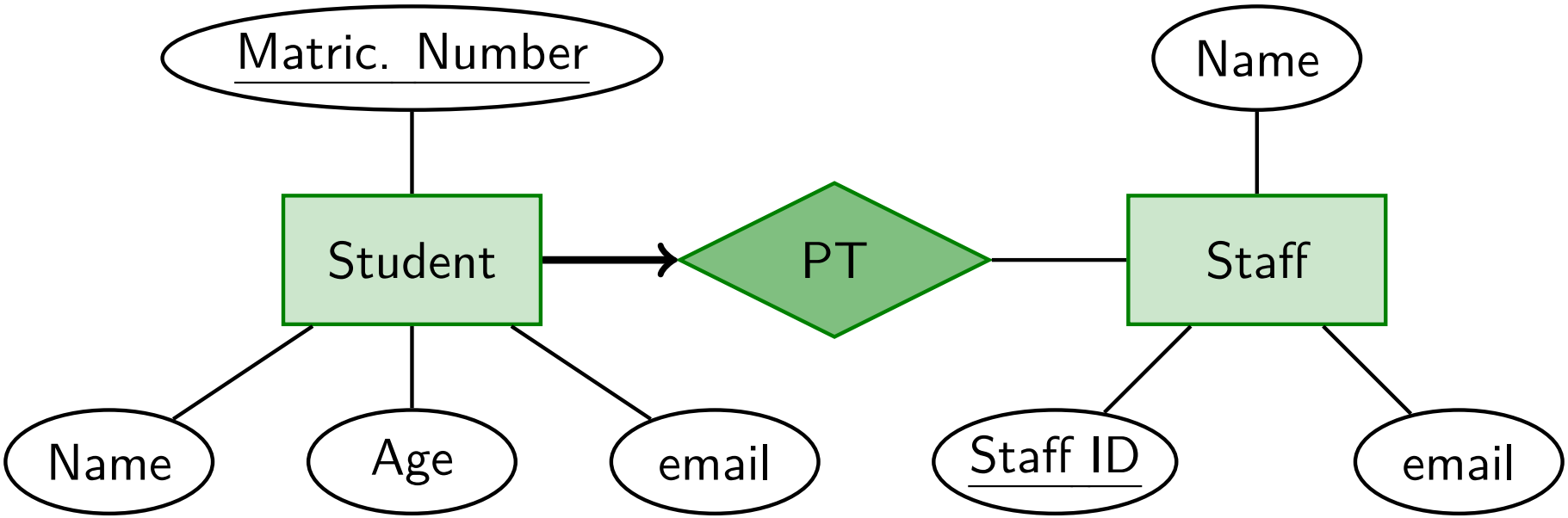
Forbidding **NULL** is in some cases a way to enforce total participation.

Mapping Key and Participation Constraints



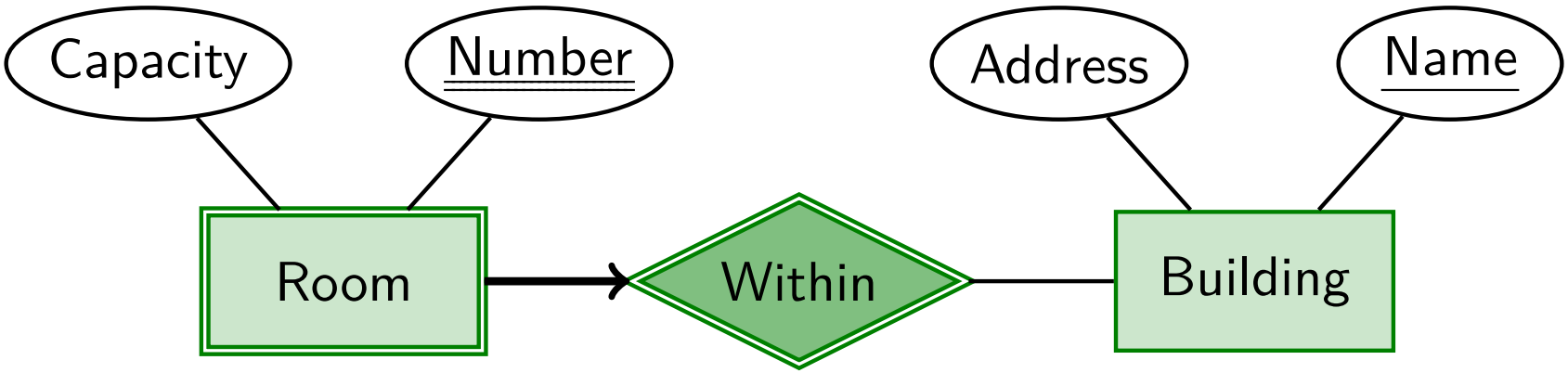
- Create a table for the source and target entities as usual.
- Add every key attribute of the target as a field in the source table.
- Declare these fields as **NOT NULL**
- Declare these fields as foreign keys.

Mapping Key and Participation Constraints




```
CREATE TABLE Student (
    matric  VARCHAR(8),     age    INTEGER,
    name    VARCHAR(20),    email  VARCHAR(25),
    pt      VARCHAR(8) NOT NULL,
    PRIMARY KEY (matric),
    FOREIGN KEY  (pt) REFERENCES Staff(staff_id) )
```

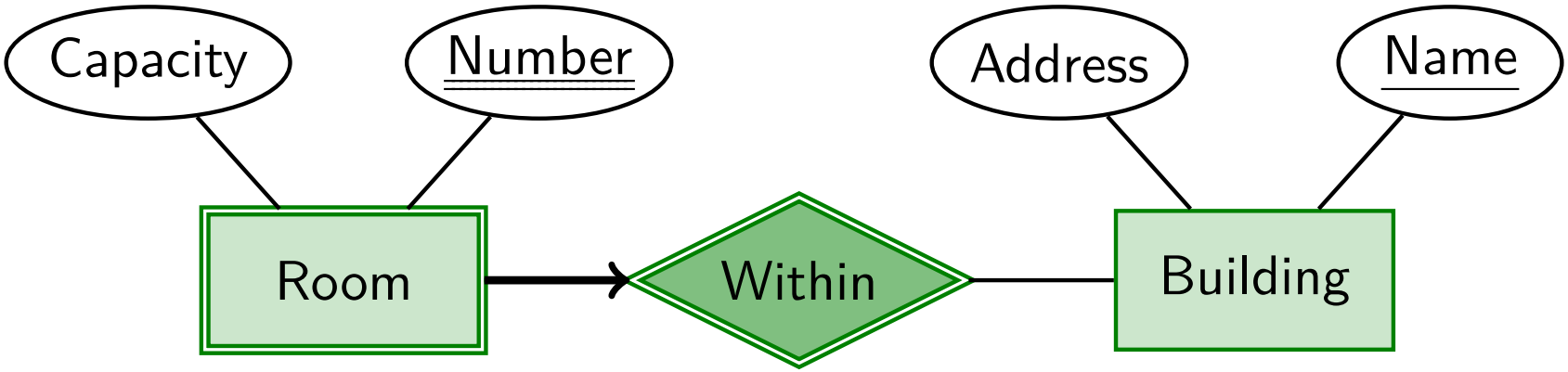
Mapping Weak Entities and Identifying Relationships



A weak entity always has a participation and key constraint with its identifying relationship, which makes things similar to the previous case.

- Create a table for the weak entity.
- Make each attribute of the weak entity a field of its table.
- Add fields for the key attributes of the identifying owner.
- Declare a composite key using key attributes from both entities.
- Declare a foreign key constraint on the identifying owner fields.
- Instruct the system to automatically delete tuples in the table when their identifying owners are deleted.

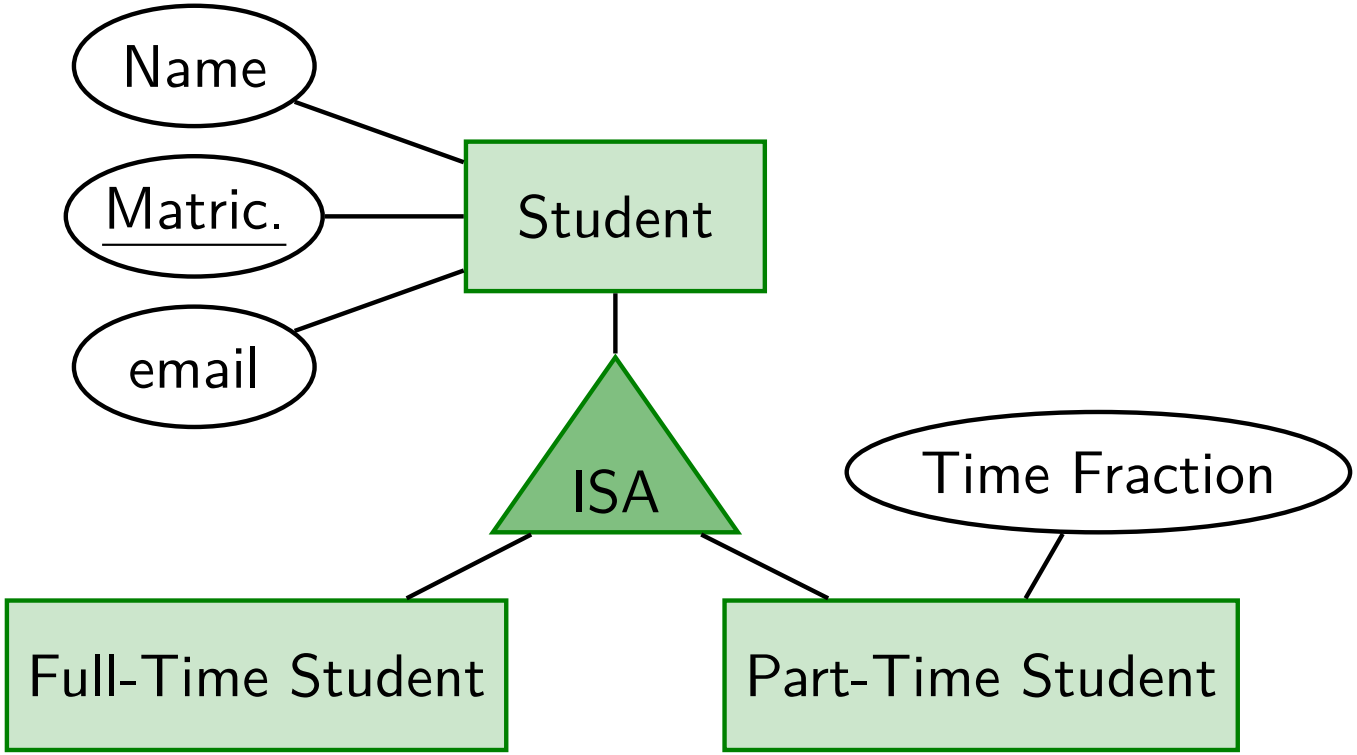
Mapping Weak Entities and Identifying Relationships




```
CREATE TABLE Room (
    number          VARCHAR(8),
    capacity        INTEGER,
    building_name   VARCHAR(20),
    PRIMARY KEY (number, building_name),
    FOREIGN KEY  (building_name)
        REFERENCES Building(name)
        ON DELETE CASCADE )
```

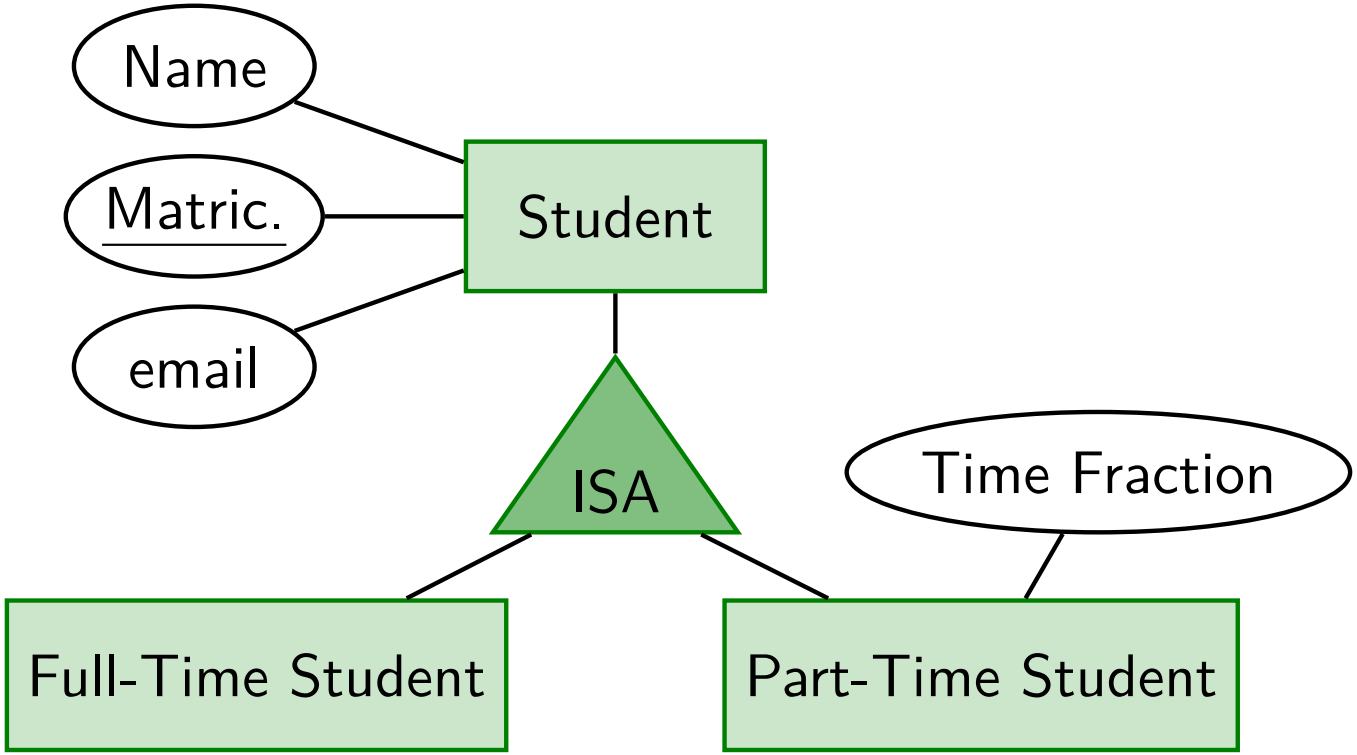
(Don't use **ON DELETE SET NULL** here)

Mapping Entity Hierarchies



- Declare a table for the superclass entity with all attributes.
- For each subclass entity declare another table using the primary key of the superclass and the extra attributes of the subclass.
- Declare the primary key from the superclass as the primary key of the subclass, with a foreign key constraint.

Mapping Entity Hierarchies




```
CREATE TABLE PartTimeStudent (
    matric   VARCHAR(8),
    fraction REAL,
    PRIMARY KEY (matric),
    FOREIGN KEY (matric) REFERENCES Student )
```

Database Textbooks (Page 1 of 2)

R. Ramakrishnan and J. Gehrke. — 3 copies in HUB

Database Management Systems. — 5 other copies

McGraw-Hill, third edition, 2003.

H. Garcia-Molina, J. Ullman, and J. Widom. — 1 copy in HUB

Database Systems: The Complete Book.

Pearson, second edition, 2008.

J. Ullman and J. Widom. — 1 copy in HUB

A First Course in Database Systems. — 1 other copy

Prentice Hall, third edition, 2009.

M. Kifer, A. Bernstein, and P. M. Lewis. — Copy in HUB

Database Systems: An Application-Oriented Approach, Introductory Version.

Pearson, second edition, 2005.

Database Textbooks (Page 2 of 2)

A. Silberschatz, H. Korth, and S. Sudarshan. 1 copy in HUB

Database System Concepts.

McGraw-Hill, sixth edition, 2010.

T. Connolly and C. Begg. 1 copy

Database System: A Practical Approach to Design, Implementation and Management.

Addison-Wesley, fourth edition, 2005.

R. Elmasri and S. Navathe. 3 copies

Fundamentals of Database Systems.

Addison-Wesley, third edition, 2000.