CS 186 Discussion 11

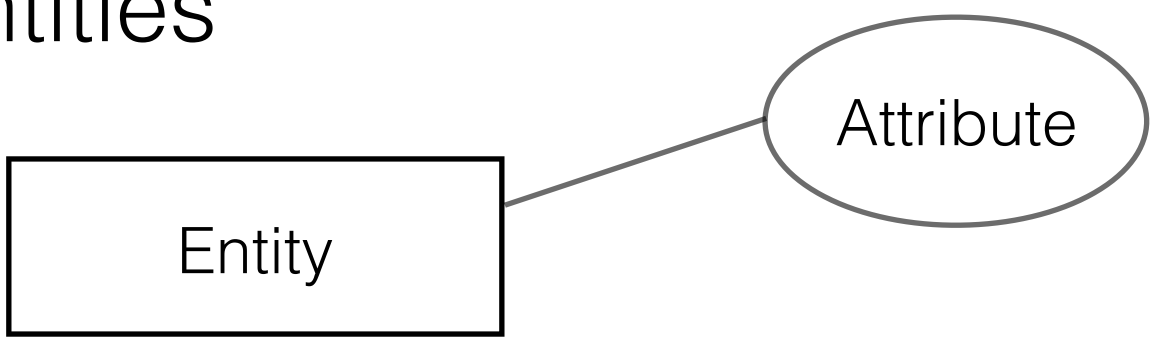
Relational Modeling
FDs, BCNF

Logistics

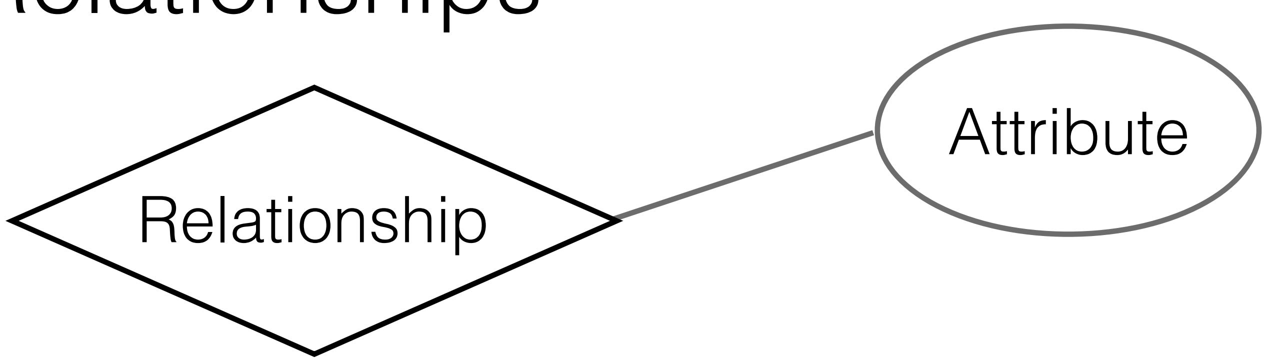
- Just a few reminders…
  - Check glookup
  - HKN Survey this Thursday
  - Final Review Session next Thursday

Relational Modeling

- Entity-Relationship model
- Entities



    - Weak Entities
- Relationships



Constraints

- Key Constraints
  - at *most* one
- Participation Constraints
  - at *least* one
- “Key constraint with total participation”
  - *exactly* one
- One-to-many? Many-to-one? One-to-one?

Constraints

- Key Constraints
  - at *most* one <- specifies many-to-one/one-to-many/one-to-one
- Participation Constraints
  - at *least* one
- "Key constraint with total participation"
  - *exactly* one

ER Diagrams Worksheet

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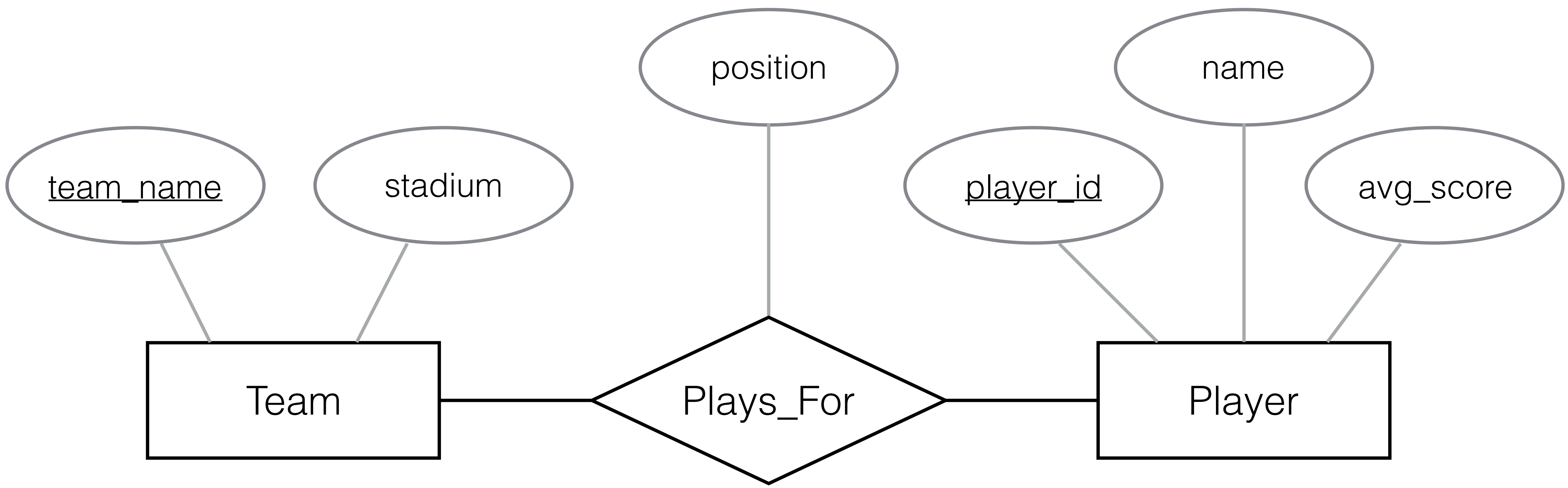

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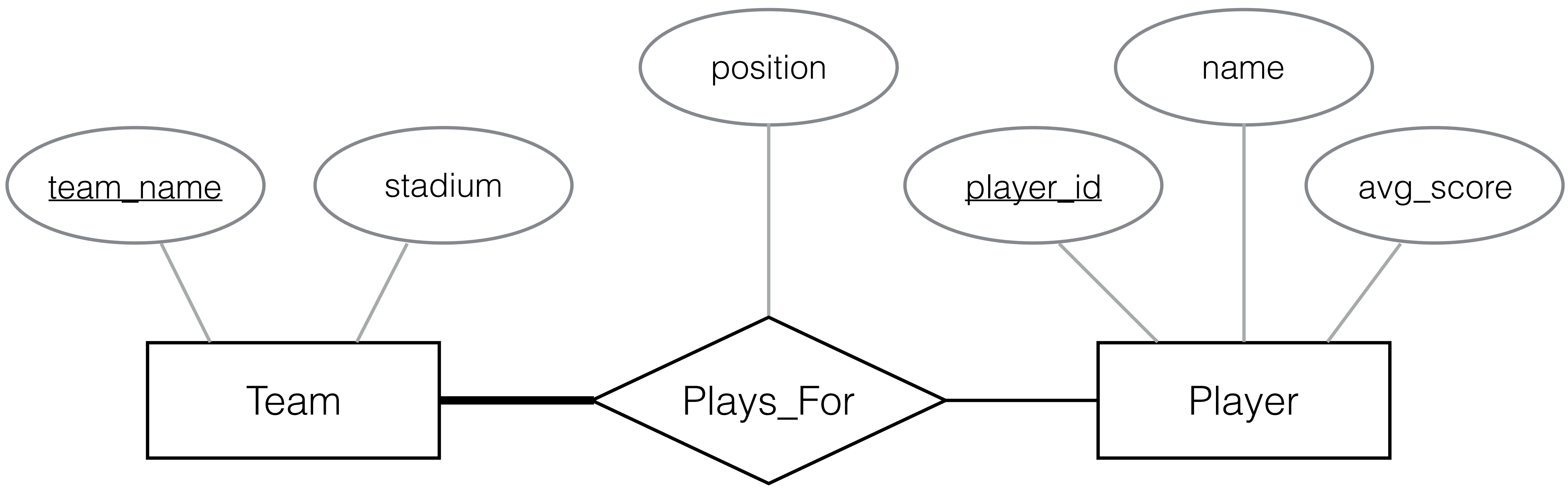

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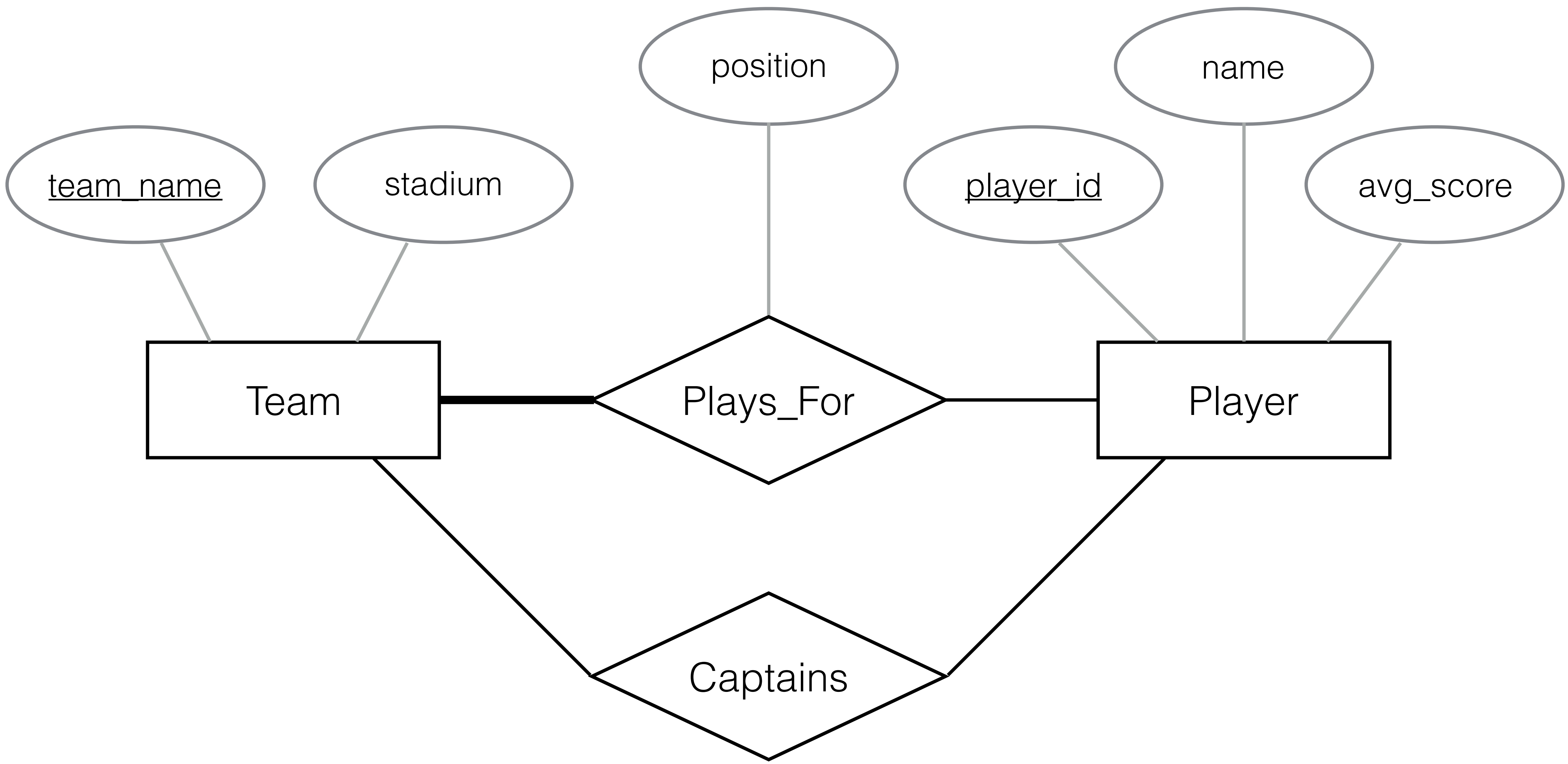

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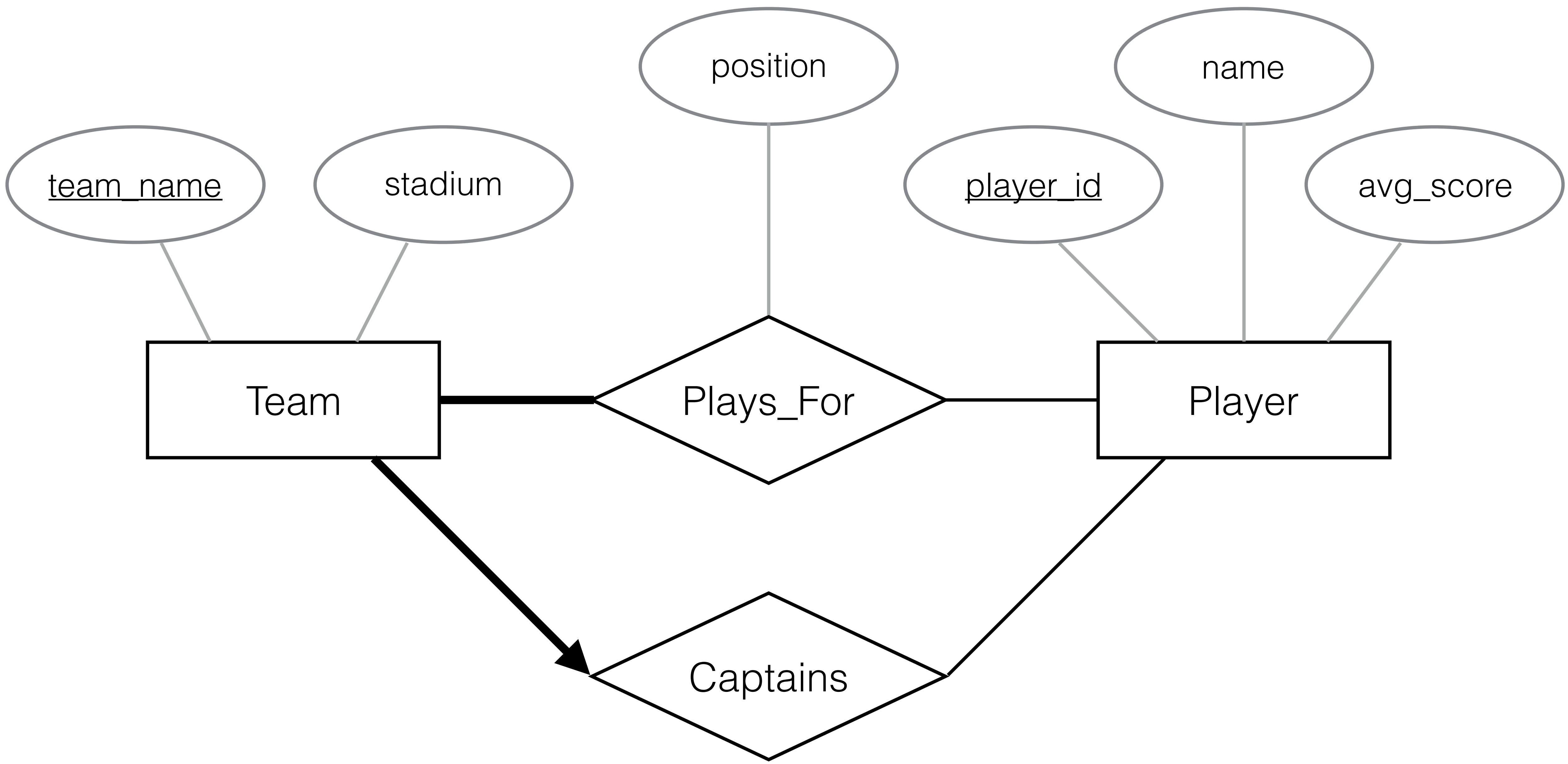
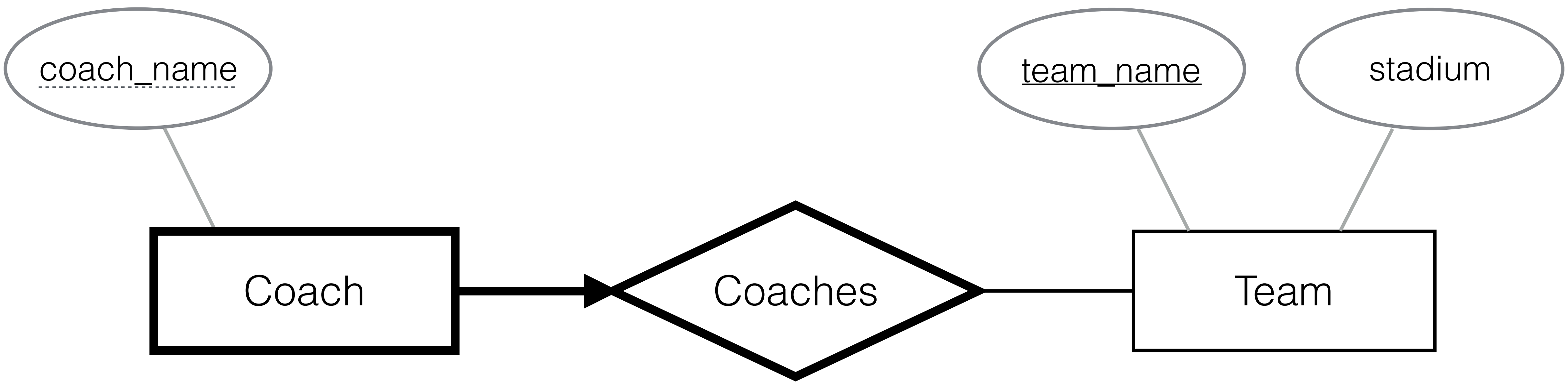


Weak Entities



Functional Dependencies

- $X \rightarrow Y$
  - X *determines* Y
  - For every pair of tuples in R, if X is the same, Y must be the same.
- $K \rightarrow$ [all attributes of R]
  - K is a superkey! Why?
  - What about primary keys?

Rules of Inference

- Armstrong's Axioms
  - Reflexivity: If $Y \subseteq X$, then $X \rightarrow Y$
  - Augmentation: If $X \rightarrow Y$, then $XZ \rightarrow YZ$
    - $XZ \rightarrow YZ$ does NOT imply $X \rightarrow Y$
  - Transitivity: If $X \rightarrow Y$ and $Y \rightarrow Z$, then $X \rightarrow Z$
- Union: If $X \rightarrow Y$ and $X \rightarrow Z$, then $X \rightarrow YZ$
- Decomposition: If $X \rightarrow YZ$, then $X \rightarrow Y$ and $X \rightarrow Z$
  - $XZ \rightarrow Y$ does NOT imply $X \rightarrow Y$ and $Z \rightarrow Y$

Closure

- Given a set of FDs F, finding the closure F^+ is <u>extremely</u> difficult; all implicit FDs are in F^+!
- Instead, lets compute <u>Attribute Closures</u>:
  - Given an attribute X,
    - "X^+ = All attributes A such that $X \rightarrow A$ is in F^+"
    - X^+ = All attributes that X determines (given F)

FD Worksheet

Flights(**F**light_no, **D**ate, f**R**om, **T**o, **P**lane_id),
ForeignKey(**P**lane_id)

Planes(**P**lane_id, t**Y**pe)

Seat(**S**eat_no, **P**lane_id, **L**egroom), ForeignKey(**P**lane_id)

What are the functional dependencies?

FD Worksheet

Flights(**F**light_no, **D**ate, f**R**om, **T**o, **P**lane_id), ForeignKey(**P**lane_id)

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What are the functional dependencies?

- FD → RTP
- P → Y
- SP → L

FD Worksheet

$F = \{AB \rightarrow C, A \rightarrow D, D \rightarrow E, AC \rightarrow B\}$

What are the attribute closures?

A:

AB:

B:

D:

FD Worksheet

$F = \{AB \rightarrow C,\ A \rightarrow D,\ D \rightarrow E,\ AC \rightarrow B\}$

What are the attribute closures?

A: ADE

AB: ABCDE

B: B

D: DE

Normal Form

- Avoids redundancies and anomalies
- Guidance on whether decomposition is needed

Boyce-Codd Normal Form

- R is in BCNF if for every FD $X \rightarrow A$ that holds over R, one of the following statements is true:
  - $A \in X$; that is, it is a trivial FD
  - X is a superkey
- No redundancy: contains only information that cannot be inferred with FDs

Normalization

- Decompose into multiple relations
  - Some problems:
    - Lossiness: Can we reconstruct the original relation?
    - Dependency Preserving: Have we lost any dependencies?
    - Some queries more expensive (need joins)

Decomposition into BCNF

- If $X \rightarrow Y$ violates BCNF…
  - Decompose R into $R - Y$ and XY
- Repeat until in BCNF (guaranteed to terminate)

- *Lossless, but <u>not necessarily</u> dependency preserving*
- *Final result depends on order of decomposition*

Worksheet: Decomposition

Decompose R = ABCDEFG into BCNF, given:

F = {AB → CD, C → EF, G → A, G → F, CE → F}

Worksheet: Decomposition

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$F = \{AB \rightarrow CD, C \rightarrow EF, G \rightarrow A, G \rightarrow F, CE \rightarrow F\}$

Decomposes into R – CD = ABEFG, and ABCD

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ABEFG decomposes into BEFG, and AG

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BEFG decomposes into BEG, and FG

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ABEFG decomposes into BEFG, and AG

BEFG decomposes into BEG, and FG

Final Relations: ABCD, AG, BEG, FG

Worksheet: Decomposition

Decompose R = ABCDEFG into BCNF, given:

$F = \{AB \rightarrow CD,\ C \rightarrow EF,\ G \rightarrow A,\ G \rightarrow F,\ CE \rightarrow F\}$

Final Relations: ABCD, AG, BEG, FG

Are dependencies preserved?

- Check: If $(F_X \cup F_Y)^+ = F^+$, dependency preserving

Lossless Join Decomposition

- Lossless join decomposition with respect to *F* if, for every instance *r* of *R*: $\pi_X(r) \bowtie \pi_Y(r) = r$

- Necessary and sufficient test:
  - R decomposed to X and Y is lossless iff:
    - $X \cap Y \rightarrow X$ OR $X \cap Y \rightarrow Y$
    - Common attributes contain key for either X or Y