DBMS

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1 ONLINE BOARD GAME SERVICE

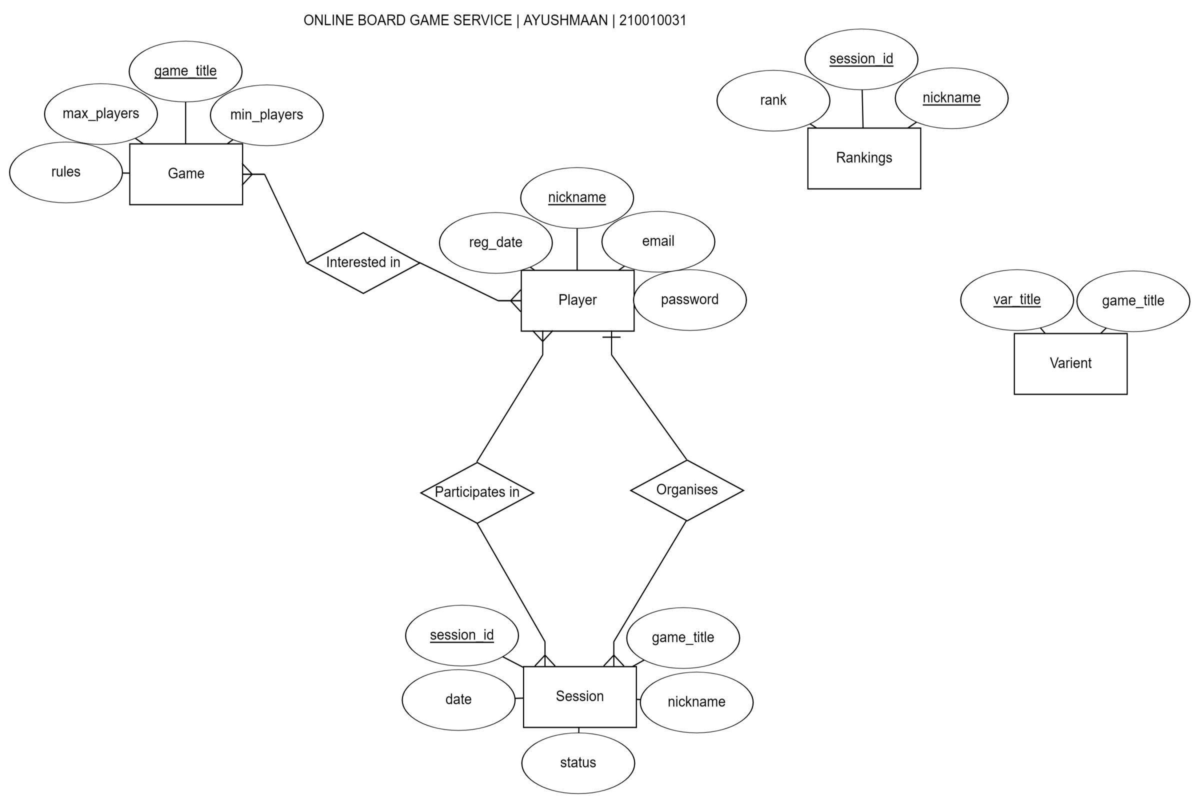

Figure 1: ER Diagram

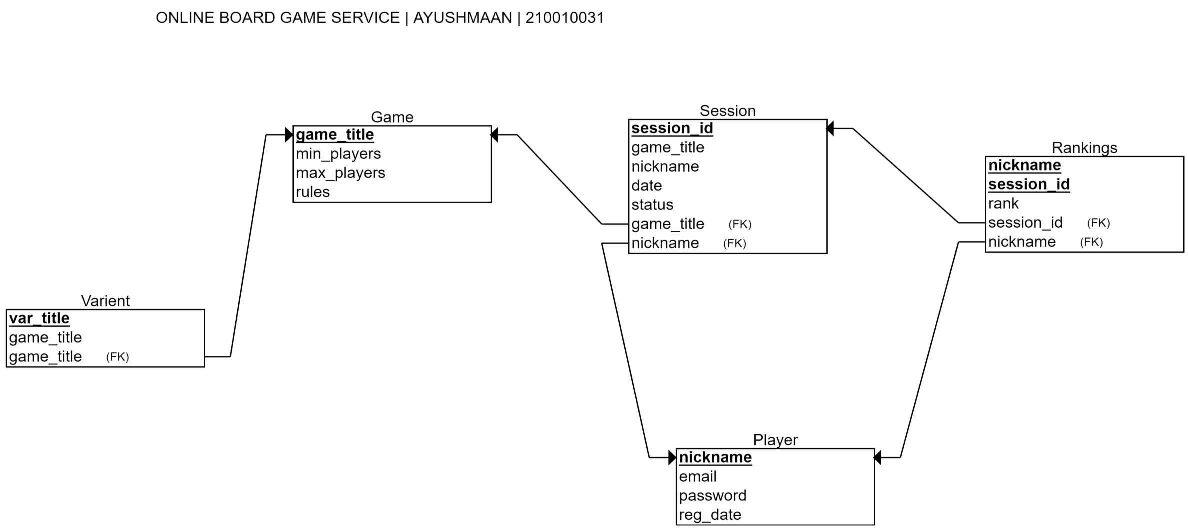

Figure 2: Relational Schema

2 2

2.1 (a)

2.1.1 Relational Algebra

$\pi_{Instructor.id,Instructor.name}(\sigma_{Instructor\_activity.a\_id=NULL}(Instructor \bowtie_{Instructor.id=Instructor\_activity.i\_id} Instructor\_activity))$

2.1.2 Tuple Relational Calculus

{t $|\exists s \in Instructor\_activity(Instructor(t) \land (t.id = s.i\_id \lor s.a\_id = NULL))$}

2.1.3 Domain Relational Calculus

{(id, name) $|\neg\forall a\_id(Instructor\_activity(a\_id, i\_id) \rightarrow (Instructor(id, name) \land id = i\_id))$}

i id	i name
1	Macron

Table 1: (a))

2.2 (b)

2.2.1 Relational Algebra

$\pi_{Instructor.name}(\sigma_{Activity.category='Boxing'}(Instructor \bowtie Instructor\_activity \bowtie Activity)) \cap \pi_{Instructor.name}(\sigma_{Activity.category='Combat'}(Instructor \bowtie Instructor\_activity \bowtie Activity))$

2.2.2 Tuple Relational Calculus

{t |Instructor(t) $\wedge \exists s(Instructor\_activity(s) \wedge Activity(s) \wedge s.category =' Boxing') \wedge \exists u(Instructor\_activity(u) \wedge Activity(u) \wedge u.category =' Combat')\}$

2.2.3 Domain Relational Calculus

{(name) |$\exists id(Instructor(id, name) \wedge \exists a\_id, i\_id(Instructor\_activity(a\_id, i\_id) \wedge Activity(a\_id, category) \wedge category =' Boxing') \wedge \exists a\_id', i\_id'(Instructor\_activity(a\_id', i\_id') \wedge Activity(a\_id', category') \wedge category' =' Combat'))\}$

i name
Jacinda

Table 2: (b))

2.3 (c)

2.3.1 Relational Algebra

$\pi_{a\_name}(Activity) - \pi_{a\_name}((\pi_{s\_id}(Student)\sigma_{level='L2'}) \bowtie Student\_activity \bowtie Activity)$

2.3.2 Tuple Relational Calculus

{t |Activity(t) $\wedge \neg \exists s(Student\_activity(s) \wedge s.a\_id = t.a\_id \wedge \exists u(Student(u) \wedge u.level =' L2' \wedge u.s\_id = s.s\_id))\}$

2.3.3 Domain Relational Calculus

{(a_name) |$\forall a\_id(Activity(a\_id, a\_name) \to \neg \exists s\_id(Student\_activity(a\_id, s\_id) \wedge \exists level(Student(s\_id, level) \wedge level =' L2'))\}$

a name
Karate
Cardio Boxing
Diving

Table 3: (c))

2.4 (d)

2.4.1 Relational Algebra

$\pi_{Instructor.i\_name}(Instructor \bowtie Instructor\_activity) - \pi_{Instructor.i\_name}((\pi_{Student.s\_id}(Student)\sigma_{level='L2'}) \bowtie Student\_activity \bowtie Instructor\_activity \bowtie Instructor)$

2.4.2 Tuple Relational Calculus

{t |Instructor(t) $\wedge \forall s(Instructor\_activity(s) \rightarrow (t.i\_id = s.i\_id \wedge \neg \exists u(Student(u) \wedge u.level =' L2' \wedge \exists v(Student\_activity(v) \wedge v.s\_id = u.s\_id \wedge v.a\_id = s.a\_id)))\}$

2.4.3 Domain Relational Calculus

{(i_name) $|\forall i\_id, a\_id(Instructor(i\_id, i\_name) \wedge Instructor\_activity(i\_id, a\_id) \rightarrow \neg \exists s\_id(Student(s\_id, level) \wedge level =' L2' \wedge \exists a\_id'(Student\_activity(s\_id, a\_id') \wedge a\_id' = a\_id))\}$

i name
Merkel
Theresea

Table 4: (d))

2.5 (e)

2.5.1 Relational Algebra

$\pi_{category}(Activity) \cap (\pi_{a\_id}((\pi_{s\_id}(\sigma_{level='L1'}(Student))) \bowtie Student\_activity) \cap \pi_{a\_id}((\pi_{s\_id}(\sigma_{level='L2'}(Student))) \bowtie Student\_activity))$

2.5.2 Tuple Relational Calculus

{t |Activity(t) $\wedge \exists s(Student\_activity(s) \wedge s.a\_id = t.a\_id \wedge \exists u(Student(u) \wedge u.level =' L1' \wedge u.s\_id = s.s\_id) \wedge \exists v(Student(v) \wedge v.level =' L2' \wedge v.s\_id = s.s\_id)\}$

2.5.3 Domain Relational Calculus

{(category) $|\forall a\_id(Activity(a\_id, category) \rightarrow (\exists s\_id(Student\_activity(a\_id, s\_id) \wedge \exists level(Student(s\_id, level) \wedge level =' L1')) \wedge (\exists s\_id'(Student\_activity(a\_id, s\_id') \wedge \exists level'(Student(s\_id', level') \wedge level' =' L2')))\}$

category
Combat
Boxing
Aquatic Sport

Table 5: (e))

3 3

(a) No, because same value of A3 is giving different value of A1 for different tuples.
$$t_1[A_3] = t_5[A_3] \;\; but \;\; t_1[A_1] \neq t_5[A_1]$$

(b) Yes.

(c) No, because same value of A2 is giving different value of A3 for different tuples.
$$t_1[A_2] = t_2[A_2] \;\; but \;\; t_1[A_3] \neq t_2[A_3]$$

(d) Yes.

(e) Yes.

Question 4

To determine if the given schema is in BCNF (Boyce-Codd Normal Form) and 3NF (Third Normal Form), we'll first analyze the functional dependencies and check if they violate the BCNF and 3NF conditions.

Given Functional Dependencies (FDs):

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FD1: B1, B2 $\rightarrow B4$
$FD2: \quad B2, B3 \rightarrow B5$
$FD3: \quad B5 \rightarrow B6$

Let's analyze BCNF and 3NF separately:

BCNF (Boyce-Codd Normal Form):

A relation schema R is in BCNF with respect to a set F of functional dependencies if, for all functional dependencies in F+ of the form $\alpha \rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R:$ at least one of the following holds:

· $\alpha \rightarrow \beta$ is a trivial functional dependency.

· α is a superkey for shcema R.

In the given schema, the primary key is $\{B1, B2, B3\}$, so we have:

FD1: $B1, B2 \rightarrow B4 \quad (X = \{B1, B2\})$ is a part of the key
FD2: $B2, B3 \rightarrow B5 \quad (X = \{B2, B3\})$ is a part of the key
FD3: $B5 \rightarrow B6 \quad (X = \{B5\})$ is not a part of the key

FD3 violates the BCNF condition because the left side $(X = \{B5\})$ is not a superkey. To bring the schema into BCNF, we need to decompose the table into smaller tables such that each table has a superkey as its primary key.

New schema to achieve BCNF:
Table 1: T1(B1, B2, B4)
Table 2: T2(B2, B3, B5)
Table 3: T3(B5, B6)

In this new schema, all tables have a superkey as their primary key, and it satisfies BCNF.

3NF (Third Normal Form):

A relation schema R is in 3NF with respect to a set F of functional dependencies if, for all functional dependencies in F+ of the form $\alpha \rightarrow \beta$, where $\alpha \subseteq R$ and $\beta \subseteq R:$ at least one of the following holds:

· $\alpha \rightarrow \beta$ is a trivial functional dependency.

· α is a superkey for shcema R.

· Each Attribute in A in $\beta - \alpha$ is contained in some candidate key of R.

In the new BCNF schema, we have two candidate keys: $\{B1, B2, B3\}$ and $\{B2, B3\}$. Now, we need to check for transitive dependencies:

FD1: $B1, B2 \rightarrow B4$ (B4 is not transitively dependent on any superkey)
FD2: $B2, B3 \rightarrow B5$ (B5 is not transitively dependent on any superkey)
FD3: $B5 \rightarrow B6$ (B6 is transitively dependent on $\{B5\}$, which is a superkey)

FD3 violates the 3NF condition because B6 is transitively dependent on a superkey. To bring the schema into 3NF, we need to further decompose the tables.

New schema to achieve 3NF:
Table 1: T1(B1, B2, B4)
Table 2: T2(B2, B3, B5)
Table 3: T3(B5, B6)
The new schema satisfies both BCNF and 3NF conditions.