Databases (Key: 1644)
Armstrong Axioms

---------- Arellanes Conde Esteban ----------

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1.1 Investigate what the Armstrong Axioms are.

The Armstrong Axioms are a set of inference rules used to infer all functional dependencies (FDs) in a relational database. They were introduced by William W. Armstrong in 1974 and provide a sound and complete basis for reasoning about FDs. These axioms are:

1. **Reflexivity:**

   If $Y \subseteq X$, then $X \to Y$.

   A superset always functionally determines its subset.

2. **Augmentation:**

   If $X \to Y X \to Y$, then $XZ \to YZ$ for any Z.

   Adding attributes to both sides of an FD preserves its validity.

3. **Transitivity:**

   If $X \to Y$ and $Y \to Z$, then $X \to Z$.

   Dependencies can be passed along chains.

Additional derived rules (not fundamental but useful) include:

- **Union:**

  If $X \to Y$ and $X \to Z$, then $X \to YZ$.

- **Decomposition:**

  If $X \to YZ$, then $X \to Y$ and $X \to Z$.

- **Pseudotransitivity:**

  If $X \to Y$ and $WY \to Z$, then $WX \to Z$.

These axioms are used to derive all possible functional dependencies in a relation.

1.2 Their relationship with Normal Forms.

Normalization is a process used to evaluate and correct table structure to minimize redundancy, thereby reducing the possibility of data anomalies. The normalization process is carried out through the application of a series of steps or states called normal forms:

- First normal form (1NF).
- Second normal form (2NF).
- Third normal form (3NF).
- Boyce-Codd normal form (BCNF).
- Fourth normal form (4NF).

1.3 The role they play in defining functional dependencies.

The Armstrong Axioms play a crucial role in defining and reasoning about functional dependencies (FDs) in a relational database. Functional dependencies are relationships between attributes, where one set of attributes (the determinant) uniquely determines another set of attributes. These FDs are essential for maintaining data integrity and ensuring proper database normalization.

The Armstrong Axioms provide the foundation for deriving all valid functional dependencies from a given set of FDs. By using the axioms—reflexivity, augmentation, and transitivity—along with derived rules such as union, decomposition, and pseudotransitivity, we can systematically determine all the functional dependencies that hold in a given relation. This is important for several reasons:

1. **Identifying Key Attributes:** The axioms help in identifying candidate keys, which are sets of attributes that can uniquely identify a tuple in a relation.
2. **Verifying Dependency Preservation:** The axioms are used to verify whether the functional dependencies are preserved during the normalization process, ensuring that no valuable relationships between attributes are lost during normalization.
3. **Minimal Covering of Functional Dependencies:** Using Armstrong's Axioms, we can reduce a set of functional dependencies to its minimal cover, which is an essential step in understanding and simplifying the structure of a relation.

By applying the Armstrong Axioms, one can derive and verify the full set of functional dependencies that help determine the proper design of a relational schema, ensuring consistency and eliminating redundancy.

1.4 Ensuring database normalization.

Database normalization aims to organize data in such a way as to reduce redundancy and eliminate undesirable characteristics like update anomalies, insertion anomalies, and deletion anomalies. This is achieved by decomposing a database into smaller, well-structured relations that adhere to specific normal forms. The role of Armstrong Axioms in this process is pivotal for ensuring that the normalization is accurate and consistent.

1. Identifying Violations of Normal Forms: The Armstrong Axioms help to determine whether a relation satisfies the conditions of various normal forms (1NF, 2NF, 3NF, BCNF, etc.). By applying these axioms, we can derive all the functional dependencies in a relation and identify any violations of the requirements for higher normal forms.

2. Minimizing Redundancy: The axioms help in understanding how to remove redundancy by decomposing relations. When a relation is decomposed into multiple smaller relations to meet higher normal forms (e.g., BCNF), the Armstrong Axioms help verify that the functional dependencies are preserved across the new relations, ensuring that normalization does not lose essential information.

3. Ensuring Dependency Preservation: One of the critical goals during normalization is to preserve functional dependencies. The Armstrong Axioms help verify that during decomposition, dependencies are preserved in the resulting schema, thereby preventing potential data inconsistencies and anomalies.

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