Module 7 Summary: Functional Dependencies and Normalization (1NF–BCNF)

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1. Armstrong's Axioms and Attribute Closure

Functional dependencies $X \to Y$ constrain valid instances. Reflexivity ($Y \subseteq X \implies X \to Y$), Augmentation ($X \to Y \implies XZ \to YZ$), and Transitivity ($X \to Y, Y \to Z \implies X \to Z$) are sound and complete. Computing X^+ in $O(|F||R|)$ determines superkeys and minimal candidate keys.

2. Normal Forms and Decomposition Guarantees

Normal Form	Condition on Non-Trivial $X \to A$	Decomposition Properties
3NF	X is a superkey OR A is prime	Always lossless + dependency-preserving
BCNF	X is a superkey	Always lossless; may lose FD preservation
4NF	Non-trivial MVD $X \twoheadrightarrow Y \implies X$ superkey	Eliminates independent multivalued redundancy

A binary split (R_1, R_2) is lossless if $(R_1 \cap R_2) \to R_1$ or $(R_1 \cap R_2) \to R_2$ holds in F^+.