More notes on BCNF/3NF/4NF/MVDs

3rd Normal Form (3NF)

- A relation R is in 3NF iff for every nontrivial FD A1…An -> B for R, one of the following is true:
  - A1…An is a superkey for R (BCNF test)
  - Each B is a ***prime*** attribute (an attribute in *some* key for R)

3NF Decomposition

- Given a relation R and set F of functional dependencies:

1. Find a minimal basis, G, for F.
2. For each FD X -> A in G, use XA as the schema of one of the relations in the decomposition.
3. If none of the sets of schemas from Step 2 is a superkey for R, add another relation whose schema is a key for R.

Multivalued dependencies

- A ***MVD*** is a constraint that two sets of attributes are ***independent*** of each other.
- A MVD A1…An ->-> B1…Bm holds in R if in every instance of R:
  - for every pair of tuples t and u that agree on all the As, we can find a tuple v in R that agrees
    - with both t and u on the As
    - with t on the Bs
    - with u on all those attributes of R that are not As or Bs
- In other words, the information in A1..An determines the values of the set of tuples for B1..Bm ***and*** those tuples are independent of any other attributes in the relation.

Rules for MVDs

- **FD promotion:** Every FD A→B is an MVD A→→B
- **Trivial MVDs:**

1. If A→→B, then A→→AB
2. If A1, A2…, An and B1, B2, …, Bm make up *all* the attributes of a relation, then A1, A2, …An →→ B1, B2, …Bm holds in the relation

- **Transitive rule:** Given A→→B and B→→C, we can infer A→→C.
- **Complementation rule:** if we know A→→B, then we know A→→C, where all the Cs are attributes not among the As or Bs.

- Note that the **splitting rule does not hold!** If A→→BC, then it is not true that A→→B and A→→C.

4th Normal Form (4NF)

- "Stronger" than BCNF.
- A relation R is in 4NF iff:
  - for all MVDs A1…An ->-> B1…Bm,
    {A1, …, An} is a superkey of R.

4NF Decomposition

- Consider relation R with set of attributes X
- A1 A2 … An →→ B1 B2 … Bm violates 4NF
- Decompose R into two relations whose attributes are:

1. The As and Bs together, i.e., {A1 A2 … An, B1, B2, …, Bm}
2. All the attributes of R which are not Bs, i.e. X – {B1, B2 …, Bm}
3. Recursively check if the new relations are in 4NF and repeat