Normalization

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Normalization: What and why?

- → A systematic approach to:
  - → Restructure tables to eliminate data redundancy (duplicated data)
  - → Eliminate Update Anomalies
    - → Insertion
    - → Deletion
    - → Modification
- → Bottom up approach
  - → Starts from the data
  - → Ends with multiple related tables, with a minimum of duplicated data

Update Anomaly

Employees' Skills

Employee ID	Employee Address	Skill
426	87 Sycamore Grove	Typing
426	87 Sycamore Grove	Shorthand
519	94 Chestnut Street	Public Speaking
519	96 Walnut Avenue	Carpentry

→ Employee 519 is shown as having different addresses on different records.

Insertion Anomaly

Faculty and Their Courses

Faculty ID	Faculty Name	Faculty Hire Date	Course Code
389	Dr. Giddens	10-Feb-1985	ENG-206
407	Dr. Saperstein	19-Apr-1999	CMP-101
407	Dr. Saperstein	19-Apr-1999	CMP-201
424	Dr. Newsome	29-Mar-2007	?

→ Until the new faculty member, Dr. Newsome, is assigned to teach at least one course, his or her details cannot be recorded.

Deletion Anomaly

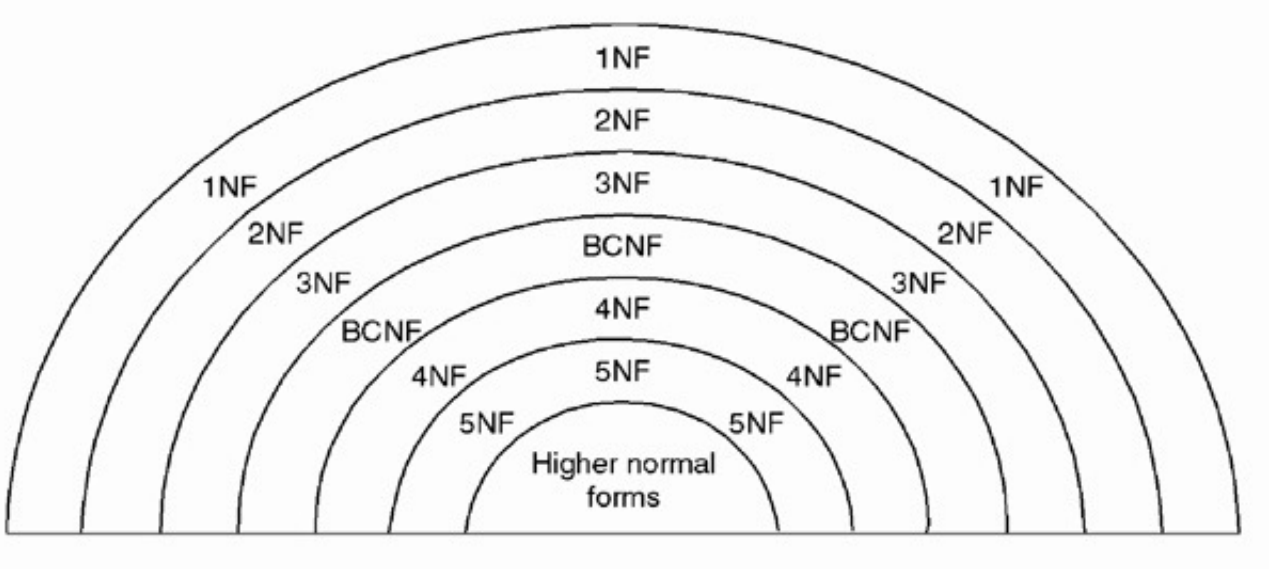
Faculty and Their Courses

Faculty ID	Faculty Name	Faculty Hire Date	Course Code
389	Dr. Giddens	10-Feb-1985	ENG-206
407	Dr. Saperstein	19-Apr-1999	CMP-101
407	Dr. Saperstein	19-Apr-1999	CMP-201

DELETE

→ All information about Dr. Giddens is lost if he or she temporarily ceases to be assigned to any courses.

Normal Forms



→ UNF: Unnormalized Form

→ NF1 – First Normal Form

→ NF2 – Second Normal Form

→ NF3 – Third Normal Form

→ BCNF – Boyce-Codd Normal Form

→ *NF4, NF5, and higher …*

→ Practical use of NF's go to BCNF, or at most NF4

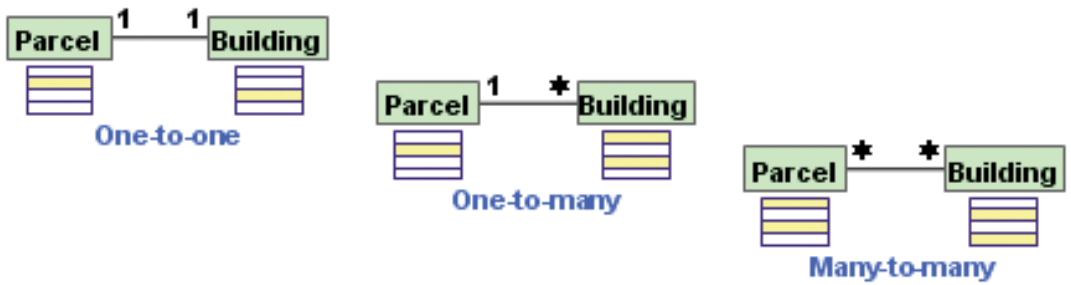
Guidelines

→ Anomalies that cause redundant work to be done during insertion into and modification of a relation, and that may cause accidental loss of information during a deletion from a relation

→ Waste of storage space due to NULLs and the difficulty of performing selections, aggregation operations, and joins due to NULL values

→ Generation of invalid and spurious data during joins on base relations with matched attributes that may not represent a proper (foreign key, primary key) relationship

Cardinalities



→ 1 - * , one to many

→ * - 1, many to one

→ * - *, many to many

→ 1 - 1, one to one

→ 0..1 - 1, zero/one to one

UNF: Unnormalized Form

→ Data idea on loan from YouTube

Customer Name	Item	Shipping Address	Newsletter	Supplier	Supplier Phone	Price
Jens Bergholm	XBOX One	Mølletoften 20, 7100 Vejle	Xbox News	Microsoft	12341324	1800
Dennis Jørgensen	Playstation 4	Vinkelvej 167, 7100 Vejle	Playstation News	Sony	23452345	1900
Hans Jensen	XBOX One, PS Vita	Kongensgade 45, 5000 Odense	Xbox News, Playstation News	Wholesale	00000000	3300
Anne Johansen	Playstation 4	Vinkelvej 167, 7100 Vejle	Playstation News	Sony	23452345	1900

NF1 – First Normal Form

→ Each column should contain atomic values – entries like “x, y” violate this rule
→ A column should contain values that are of the same type
→ Each row must be unique

Customer Name	Item	Shipping Address	Newsletter	Supplier	Supplier Phone	Price
Jens Bergholm	XBOX One	Mølletoften 20, 7100 Vejle	Xbox News	Microsoft	12341324	1800
Dennis Jørgensen	Playstation 4	Vinkelvej 167, 7100 Vejle	Playstation News	Sony	23452345	1900
Hans Jensen	XBOX One, PS Vita	Kongensgade 45, 5000 Odense	Xbox News, Playstation News	Wholesale	00000000	3300
Anne Johansen	Playstation 4	Vinkelvej 167, 7100 Vejle	Playstation News	Sony	23452345	1900

ID	Customer Name	Item	Shipping Address	Zip	City	Newsletter	Supplier	Supplier Phone	Price
1	Jens Bergholm	XBOX One	Mølletoften 20	7100	Vejle	Xbox News	Microsoft	12341324	1800
2	Dennis Jørgensen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900
3	Hans Jensen	XBOX One	Kongensgade 45	5000	Odense	Xbox News	Microsoft	12341324	1800
3	Hans Jensen	PS Vita	Kongensgade 45	5000	Odense	Playstation News	Sony	23452345	1500
4	Anne Johansen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900

Functional Dependencies

→ A strong connection between two attributes in a table

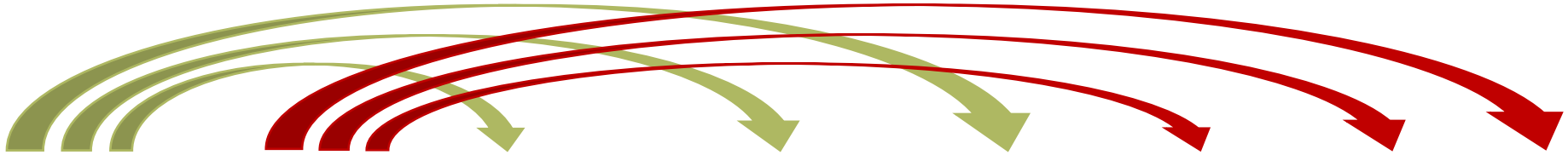
→ Denoted as A → B

→ A functionally determines B, or B is functionally dependent on A.

→ Customer Name and Item is the **Determinant**.

→ Customer Name → {Shipping Address, City, Newsletter}

→ Item → {Supplier, Supplier Phone, Price}



ID	Customer Name	Item	Shipping Address	Zip	City	Newsletter	Supplier	Supplier Phone	Price
1	Jens Bergholm	XBOX One	Mølletoften 20	7100	Vejle	Xbox News	Microsoft	12341324	1800
2	Dennis Jørgensen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900
3	Hans Jensen	XBOX One	Kongensgade 45	5000	Odense	Xbox News	Microsoft	12341324	1800
3	Hans Jensen	PS Vita	Kongensgade 45	5000	Odense	Playstation News	Sony	23452345	1500
4	Anne Johansen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900

Partial Dependencies

→ An Xbox one purchase does not require you to be “Jens Bergholm”

→ But there is a dependency, as “Jens Bergholm” purchased this item

ID	Customer Name	Item	Shipping Address	Zip	City	Newsletter	Supplier	Supplier Phone	Price
1	Jens Bergholm	XBOX One	Mølletoften 20	7100	Vejle	Xbox News	Microsoft	12341324	1800
2	Dennis Jørgensen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900
3	Hans Jensen	XBOX One	Kongensgade 45	5000	Odense	Xbox News	Microsoft	12341324	1800
3	Hans Jensen	PS Vita	Kongensgade 45	5000	Odense	Playstation News	Sony	23452345	1500
4	Anne Johansen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900

NF2 – Second Normal Form

→ No partial Dependencies

Customer Table

ID	Customer Name	Shipping Address	Zip	City	Newsletter
1	Jens Bergholm	Mølletoften 20	7100	Vejle	Xbox News
2	Dennis Jørgensen	Vinkelvej 167	7100	Vejle	Playstation News
3	Hans Jensen	Kongensgade 45	5000	Odense	Xbox News
3	Hans Jensen	Kongensgade 45	5000	Odense	Playstation News
4	Anne Johansen	Vinkelvej 167	7100	Vejle	Playstation News

Order Table

Customer_Id	Product_Id
1	1
2	2
3	1
3	3
4	2

Product Table

ID	Item	Supplier	Supplier Phone	Price
1	XBOX One	Microsoft	12341324	1800
2	Playstation 4	Sony	23452345	1900
3	PS Vita	Sony	23452345	1500

NF3 – Third Normal Form

→ A table is said to be in 3NF, if and only if:

→ That table is in the second normal form (2NF)

→ Every attribute in the table that do not belong to a candidate key should directly depend on every candidate key of that table.

Customer Table

ID	Customer Name	Shipping Address	Newsletter	Zip	City
1	Jens Bergholm	Mølletoften 20	Xbox News	7100	Vejle
2	Dennis Jørgensen	Vinkelvej 167	Playstation News	7100	Vejle
3	Hans Jensen	Kongensgade 45	Xbox News	5000	Odense
3	Hans Jensen	Kongensgade 45	Playstation News	5000	Odense
4	Anne Johansen	Vinkelvej 167	Playstation News	7100	Vejle

Order Table

Customer_Id	Product_Id
1	1
2	2
3	1
3	3
4	2

Product Table

ID	Item	Price	Supplier_ID
1	XBOX One	1800	1
2	Playstation 4	1900	2
3	PS Vita	1500	2

Supplier Table

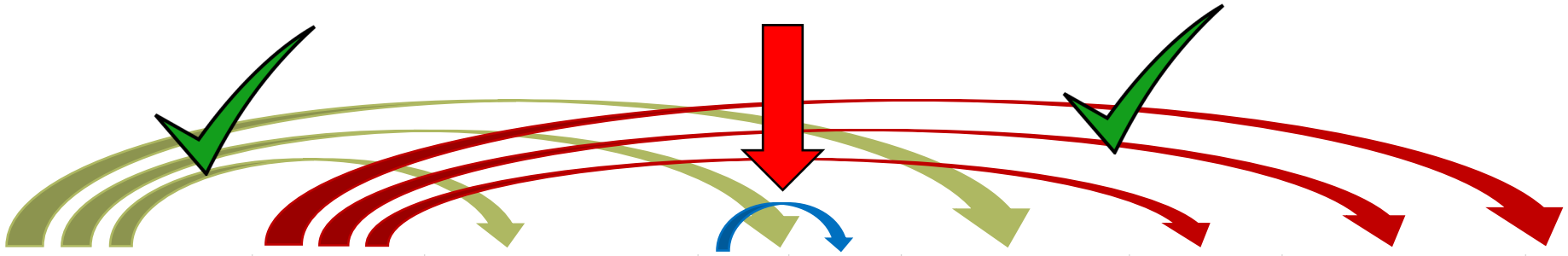
ID	Name	Phone
1	Microsoft	12341234
2	Sony	23452345

BCNF – Boyce–Codd Normal Form

→ AKA: NF3.5

→ If a relational schema is in BCNF then all redundancy based on functional dependency has been removed, although other types of redundancy may still exist.

→ Or said in another way: Even when a database is in 3rd Normal Form, still there would be anomalies resulted if it has more than one Candidate Key.



ID	Customer Name	Item	Shipping Address	Zip	City	Newsletter	Supplier	Supplier Phone	Price
1	Jens Bergholm	XBOX One	Mølletoften 20	7100	Vejle	Xbox News	Microsoft	12341324	1800
2	Dennis Jørgensen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900
3	Hans Jensen	XBOX One	Kongensgade 45	5000	Odense	Xbox News	Microsoft	12341324	1800
3	Hans Jensen	PS Vita	Kongensgade 45	5000	Odense	Playstation News	Sony	23452345	1500
4	Anne Johansen	Playstation 4	Vinkelvej 167	7100	Vejle	Playstation News	Sony	23452345	1900

BCNF – Boyce–Codd Normal Form

→ If a relational schema is in BCNF then all redundancy based on functional dependency has been removed, although other types of redundancy may still exist.

Customer Table

ID	Customer Name	Shipping Address	Newsletter	Zip_ID
1	Jens Bergholm	Mølletoften 20	Xbox News	7100
2	Dennis Jørgensen	Vinkelvej 167	Playstation News	7100
3	Hans Jensen	Kongensgade 45	Xbox News	5000
3	Hans Jensen	Kongensgade 45	Playstation News	5000
4	Anne Johansen	Vinkelvej 167	Playstation News	7100

Zip Table

Zip	Name
5000	Odense
7100	Vejle

Order Table

Customer_Id	Product_Id
1	1
2	2
3	1
3	3
4	2

Product Table

ID	Item	Price	Supplier_ID
1	XBOX One	1800	1
2	Playstation 4	1900	2
3	PS Vita	1500	2

Supplier Table

ID	Name	Phone
1	Microsoft	12341234
2	Sony	23452345

NF4 – Fourth Normal Form

→ All columns can be determined only by the key in the table and no other column

→ No Multi-valued Dependencies

→ Or said in another way: If no database table instance contains two or more, independent and multivalued data describing the relevant entity, then it is in 4th Normal Form.

Newsletters Tab.

ID	Newsletter
1	Xbox News
2	Playstation News

Subscriptions Table

Newsletter_ID	Customer_ID
1	1
2	2
1	3
2	3
2	4

Customer Table

ID	Customer Name	Shipping Address	Zip_ID
1	Jens Bergholm	Mølletoften 20	7100
2	Dennis Jørgensen	Vinkelvej 167	7100
3	Hans Jensen	Kongensgade 45	5000
4	Anne Johansen	Vinkelvej 167	7100

Zip Table

Zip	Name
5000	Odense
7100	Vejle

Order Table

Customer_Id	Product_Id
1	1
2	2
3	1
3	3
4	2

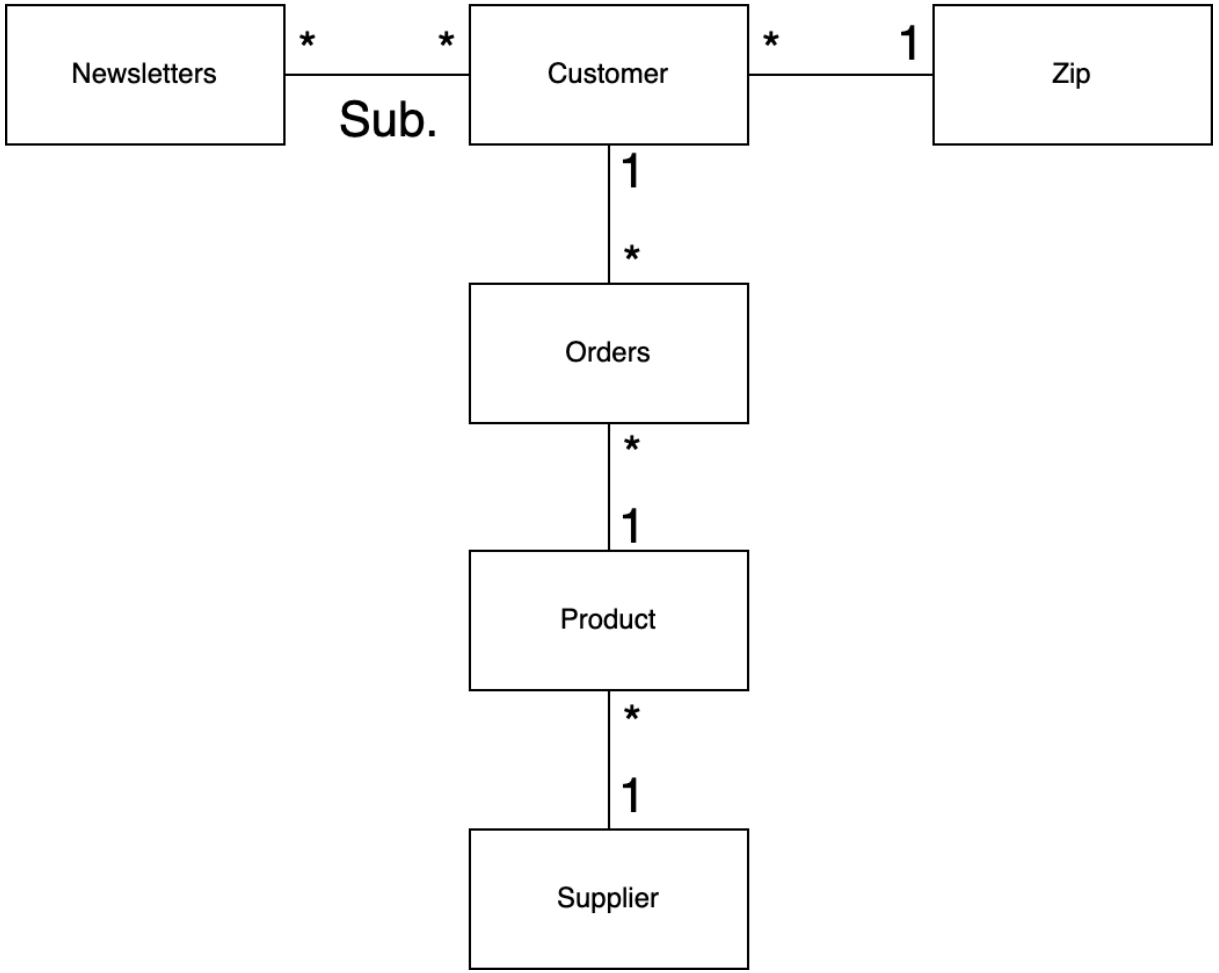
Product Table

ID	Item	Price	Supplier_ID
1	XBOX One	1800	1
2	Playstation 4	1900	2
3	PS Vita	1500	2

Supplier Table

ID	Name	Phone
1	Microsoft	12341234
2	Sony	23452345

Cardinalities



Recap with using simple rules

→ Rows identify single entities

→ A tables attributes should be directly related

  → Think object oriented, or about physical entities

→ Avoid Data Redundancy

→ Preserve Relationships

Working from NF1

Entity

Entity + Redundancy

Entity + Redundancy

Entity + Redundancy

Entity + Redundancy

ID	Customer Name	Shipping Address	Zip	City	Newsletter	Item	Price	Supplier	Supplier Phone
1	Jens Bergholm	Mølletoften 20	7100	Vejle	Xbox News	XBOX One	1800	Microsoft	12341324
2	Dennis Jørgensen	Vinkelvej 167	7100	Vejle	Playstation News	Playstation 4	1900	Sony	23452345
3	Hans Jensen	Kongensgade 45	5000	Odense	Xbox News	XBOX One	1800	Microsoft	12341324
3	Hans Jensen	Kongensgade 45	5000	Odense	Playstation News	PS Vita	1500	Sony	23452345
4	Anne Johansen	Vinkelvej 167	7100	Vejle	Playstation News	Playstation 4	1900	Sony	23452345

Redundancy

Live Demo

Pay attention, and don't try to replicate what I do right now!

You will have time to do that afterwards.

Exercises

Doctor Number	Name	Room Address	Phone	Department Id	Designation	Charges per hour	Patient Number	Patient Name	CPR Number	Patient Phone	Room Number	Room Type	Bed Number
D1	Dr. Peterson	U45	12341234	Neurology	Professor	5000	P1	Jan	190582-1113	98769876	R2	Normal	B1
D1	Dr. Peterson	U45	12341324	Neurology	Professor	5000	P5	Peter	300175-2359	87658765	R2	Normal	B1
D1	Dr. Peterson	U45	12341234	Neurology	Professor	5000	P7	Jens	041298-1257	76547654	Null		Null
D2	Dr. Jensen	U32	24352435	Orthopedic	Professor	5000	P4	Ole	051165-9863	65436543	R2	Normal	B1
D2	Dr. Jensen	U32	23452345	Orthopedic	Professor	5000	P7	Jens	041298-1257	76547654	R4	Two Bed	B5
D2	Dr. Jensen	U32	23452435	Orthopedic	Professor	5000	P9	Anna	260792-1050	54325432	R4	Two Bed	B7
D4	Dr. Poetch	U186	34563456	ENT/Neurology	Assistant Professor	3000	P10	Dennis	150893-1151	43214321	Null		Null
D4	Dr. Poetch	U186	34563456	ENT/Neurology	Assistant Professor	3000	P1	Jan	190582-1113	98769876	R5	Special	B8
D5	Dr. Neurenheim	U150	45674567	Skin/Orthepoedic	Assistant Professor	3000	P12	Ahmed	010211-7853	32103210	Null		Null
D5	Dr. Neurenheim	U150	45674567	Skin/Orthepoedic	Assistant Professor	3000	P13	Annika	051285-8072	21092109	R6	Special	B9

→ From the dataset above:
  → Normalize the table to the fourth normal form.
  → Create SQL Script to generate all the tables, and the associated data.
→ Query the database for all patients of Dr. Peterson, and find their name, cpr, what room they were in, and the bed number.