

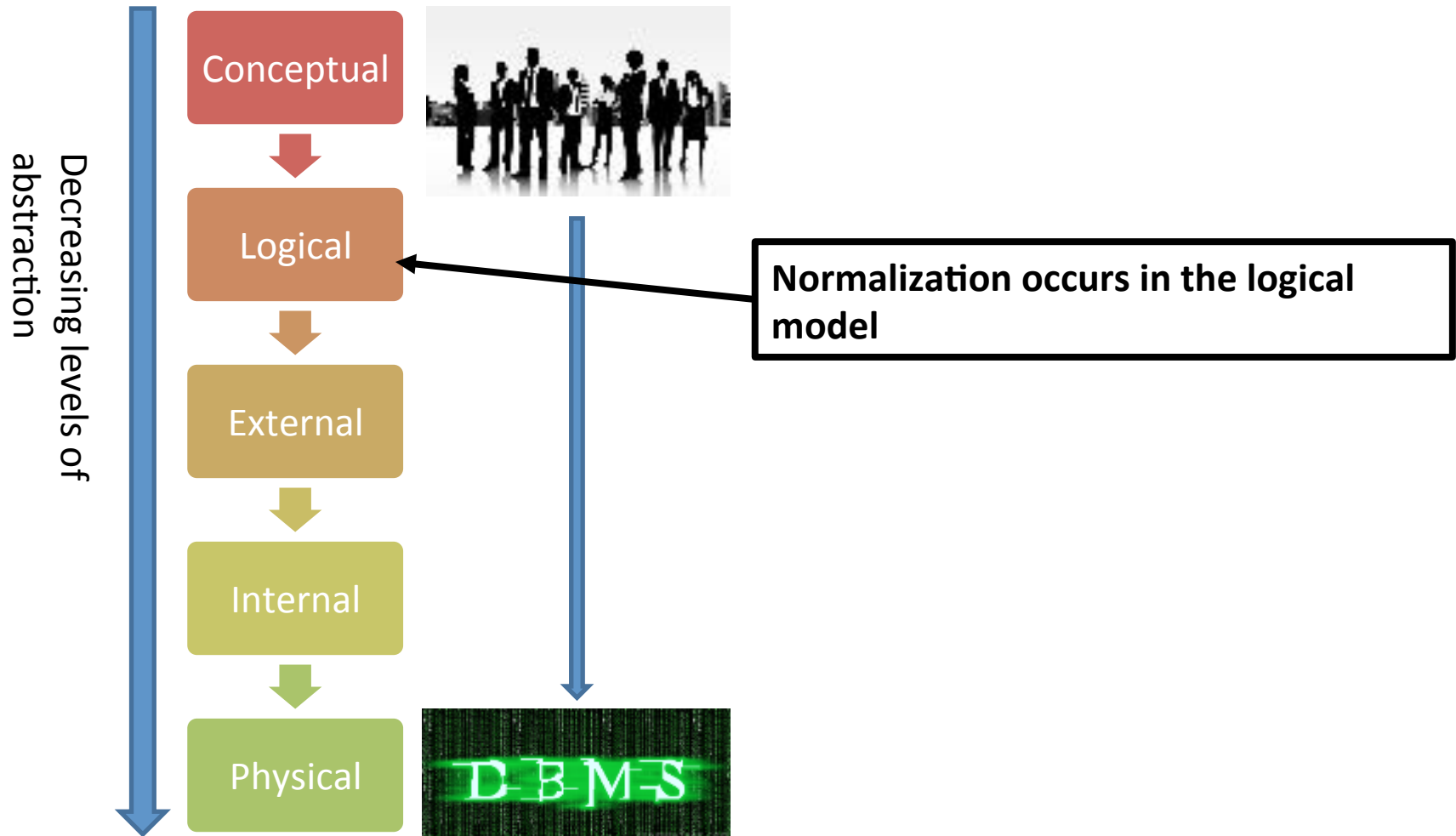
What Is Normalization?

Normalization

- The process of systematically eliminating dependencies in relations
- Reduces data redundancy
- Improves data consistency
- Reduces database maintenance activity

*no duplicates
values*

Levels of Data Model Abstraction



Why Normalize?

- To find the most efficient way of storing data
- To eliminate **anomalies**
 - **Insertion anomaly**
 - How can we control what data go into our database? “Family & Friends” vs. “Family and Friends”
 - Normalization ensures data are entered in a controlled fashion according to the business rules.
 - **Update anomaly**
 - How do we ensure that all necessary rows change when needed?
 - Normalization ensures updates happen to all necessary rows.
 - **Selection anomaly**
 - How do we ensure that we are getting all of the relevant rows?
 - Normalization makes the data organized in such a way that we can ensure all necessary rows are read.
 - **Delete anomaly**
 - If we need to remove data, are you sure you got all of it?
 - Normalization ensures that if we remove a record, all instances of that data are removed.

permutations

control

be able
2 change

reduce
redundancy

Normalization

Project	Category	Assigned To	Est. Start	Est. Finish	Est. Work	Est. Duration
Project 1	Restrung Basses	Tony Levine	1/4/2013	3/4/2013	210	60
Project 2	Hang lights	Paz Lenchantin	1/20/2013	2/21/2013	400	31
Project 3	Restrung Basses	Frank Bello	2/6/2013	4/16/2013	500	70
Project 4	Unload trailer	Sean Yseult	3/8/2013	3/18/2013	250	10
Project 5	Unload the trailer	Bello, Frank	3/19/2013	4/29/2013	300	40
Project 6	Set up sound	Paz Lenchantin	4/10/2013	4/20/2013	500	10
Project 7	Sound Check	Tony Levin	4/18/2013	5/12/2013	750	24
Project 8	Dress Rehearsal	Tony Levin	5/12/2013	6/22/2013	450	40

why we want 2 normalize



The Normal Forms

Normal Forms

- State of a relation where certain rules regarding the relation, its data, and its relationships with other relations are satisfied.
- Many normal forms exist. We're looking at 0NF to 3NF.

Zeroth Normal Form (0NF)

- Data in “sort of” a spreadsheet format.
- “cells” of the spreadsheet contain multivalued fields.
- Changes to the data or metadata could possibly require redesigning the whole data set.

more than 1 value

Virtual City Public Library

Card	Patrons	Items Loaned
4844124	Rusty Kage, <u>Lucyanna Hotsoss</u>	Books: Haynes Repair Manual - Toyota Camry, Due: 3/25/2017 Movies (DVD): Rush, Due: 3/24/2017
9308009	Dusty Rhoades	Books: Wylde, Z., & Hendrikx, E. (2012). Bringing metal to the children: The complete Berzerker's guide to world tour domination. New York: William Morrow. Due: 4/15/2017
7681891	Randall Graves	Movies (VHS): Navy Seals Due: 6/9/2017
7465947	Caitlyn Bree	Books: Asian Fashion Design for Dummies Due: 6/12/2017
7757391	Connor Murphy	eBooks: The Jungle, Upton Sinclair

First Normal Form (1NF)

- Multivalued attributes are broken out. Each row/column pair has a discrete value.
- Creates more duplication in the data.

PatronCard	PatronFirstName	PatronLastName	LoanedItemType	LoanedItemForm	LoanedItemDueDate	ItemTitle	AuthorFirstName	AuthorLastName
4844124	Rusty	Kage	Book		3/25/2017	Haynes Repair Manual - Toyota Camry		
4844124	Rusty	Kage	Movie	DVD	3/24/2017	Rush		
4844124	Lucyanna	Hotsoss	Book		3/25/2017	Haynes Repair Manual - Toyota Camry		
4844124	Lucyanna	Hotsoss	Movie	DVD	3/24/2017	Rush		
9308009	Dusty	Rhodes	Book		4/15/2017	Bringing metal to the children: The complete Berzerker's guide to world tour domination	Zakk	Wylde
9308009	Dusty	Rhodes	Book		4/15/2017	Bringing metal to the children: The complete Berzerker's guide to world tour domination	Erik	Hendrilkx
7681891	Randall	Graves	Movie	VHS	6/9/2017	Navy Seals		
7465947	Caitlyn	Bree	Book		6/12/2017	Asian Fashion Design for Dummies		
7757391	Connor	Murphy	Book	Electronic		The Jungle	Upton	Sinclair

Second Normal Form (2NF)

- In 1NF AND any partial functional dependencies have been removed.

PatronCard
4844124
9308009
7681891
7465947
7757391

PatronFirstName	PatronLastName
Rusty	Kage
Lucyanna	Hotsoss
Dusty	Rhodes
Randall	Graves
Caitlyn	Bree
Connor	Murphy

LoanedItemType	LoanedItemFormat
Book	
Movie	DVD
Movie	VHS
Book	Electronic

ItemTitle
Haynes Repair Manual - Toyota Camry
Rush
Bringing metal to the children: The complete Berzerker's guide to world tour domination
Navy Seals
Asian Fashion Design for Dummies
The Jungle

LoanedItemDueDate
3/25/2017
3/24/2017
4/15/2017
6/9/2017
6/12/2017

Third Normal Form

- In 2NF AND all transitive dependencies have been removed.
 - Non-key attributes are identified only by the primary key.

PatronFirstName	PatronLastName
Rusty	Kage
Lucyanna	Hotsoss
Dusty	Rhodes
Randall	Graves
Caitlyn	Bree
Connor	Murphy

PatronCard
4844124
9308009
7681891
7465947
7757391

LoanedItemType
Book
Movie

LoanedItemFormat
DVD
VHS
Electronic

ItemTitle
Haynes Repair Manual - Toyota Camry
Rush
Bringing metal to the children: The complete Berzerker's guide to world tour domination
Navy Seals
Asian Fashion Design for Dummies
The Jungle

LoanedItemDueDate
3/25/2017
3/24/2017
4/15/2017
6/9/2017
6/12/2017

Other Normal Forms

- Boyce-Codd Normal Form
 - All remaining anomalies have been removed (only one primary key).
- Fourth Normal Form (4NF)
 - All multivalued dependencies have been removed.
- Fifth Normal Form (5NF)
 - Any remaining anomalies have been removed.

Dependencies and Keys

Candidate Keys

- Attribute(s) that uniquely identifies a row in a relation
- Given a data set in 1NF, what data points would you have to know to identify a specific row in the set?

Candidate Keys

PatronCard	PatronFirstName	PatronLastName	LoanedItemType	LoanedItemForm	LoanedItemDueDate	ItemTitle	AuthorFirstName	AuthorLastName
4844124	Rusty	Kage	Book		3/25/2017	Haynes Repair Manual - Toyota Camry		
4844124	Rusty	Kage	Movie	DVD	3/24/2017	Rush		
4844124	Lucyanna	Hotsoss	Book		3/25/2017	Haynes Repair Manual - Toyota Camry		
4844124	Lucyanna	Hotsoss	Movie	DVD	3/24/2017	Rush		
9308009	Dusty	Rhodes	Book		4/15/2017	Bringing metal to the children: The complete Berzerker's guide to world tour domination	Zakk	Wylde
9308009	Dusty	Rhodes	Book		4/15/2017	Bringing metal to the children: The complete Berzerker's guide to world tour domination	Erik	Hendrilkx
7681891	Randall	Graves	Movie	VHS	6/9/2017	Navy Seals		
7465947	Caitlyn	Bree	Book		6/12/2017	Asian Fashion Design for Dummies		
7757391	Connor	Murphy	Book	Electronic		The Jungle	Upton	Sinclair

Candidate Keys

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7757391	Connor	Murphy	Book	Electronic		The Jungle	Upton	Sinclair

white: dependent

Functional Dependencies

- Constraint between two attributes in which the value of one attributes is determined by another
- There are three dependency conditions that must be tested:
 1. **Functional Dependence**—any non-key attributes which are FD on the PK
 2. **Partial Functional Dependence**—any non-key attributes which are FD on *part* of the PK
 3. **Transitive Functional Dependence**—any non-key attributes which are FD on *some other* non-key attribute(s)

PatronCard	PatronFirstName	PatronLastName	LoanedItemType	LoanedItemFormat	LoanedItemDueDate	ItemTitle	AuthorFirstName	AuthorLastName
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The rule for 1st Normal Form:

A relation in 1NF can have no multivalued attributes. → go back 2 videos

Converting to 1NF

First Normal Form

- Each field needs to be **scalar** (only one discrete value).
- Best to copy the data to a tabular format first.
- Creates duplications in the data.
 - Helpful for identifying dependencies!

Purchase Order

Electric Controls Company
12582 Camino Del Rio
San Diego, CA 92110-4264

To: US Electrical Controls
14878 Freemont Avenue
Suite 1800
St. Louis, MO 63127-5588

P.O. Number 100001

Please include this number on all
invoices and shipping documents.

P.O. Date January 14, 2005

Vendor Number 1007

Expected Ship Date January 29, 2005

Your Item Number	Our Item Number	Description	Quantity	Price	Extension
240-100-SW284	102	Switch, DPDT 240v 100a	50	\$14.96	\$748.00
240-100-SW184	105	Switch, SPDT 240v 100a	100	\$9.47	\$947.00
240-50-SW236	112	Switch, DPST 240v 50a	80	\$8.66	\$692.80
120-40-CB79	115	Circuit breaker, 120v 40a	100	\$6.95	\$695.00
Purchase Order Total					\$3,082.80

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Purchase Order Total					\$3,082.80

Vname	VAddr1	VAddr2	VCity	VState	VPostalCode	PON
US Electrical Controls	14878 Freemont Ave	Suite 1800	St Louis	MO	63127-5588	1000

Purchase Order

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Purchase Order Total					\$3,082.80

PONumber	PODate	VNumber	POShipDate
100001	1/14/2005	1007	1/29/2005

Purchase Order

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e VItemNum	ItemNum	Descr	Qty	Price	Ext	POTotal
5 240-100-SW284	102	Switch, DPDT 240v 100a	50	\$ 14.96	\$ 748.00	\$ 3,082.80
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Purchase Order Total					\$3,082.80

Vname	VAddr1	VAddr2	VCity	VState	VPostalCode	PONumber	PODate	VNumber	POShipDate	VItemNum	ItemNum	Descr	Qty	Price	Ext	POTotal
US Electrical Controls	14878 Freemont Ave	Suite 1800	St Louis	MO	63127-5588	100001	1/14/2005	1007	1/29/2005	240-100-SW284	102	Switch, DPDT 240v 100a	50	\$ 14.96	\$ 748.00	\$ 3,082.80
										240-100-SW184	105	Switch, SPDT 240v 100a	100	\$ 9.47	\$ 947.00	
										240-50-SW236	112	Switch, DPDT 240v 50a	80	\$ 8.66	\$ 692.80	
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US Electrical Controls	14878 Freemont Ave	Suite 1800	St Louis	MO	63127-5588	100001	1/14/2005	1007	1/29/2005	120-40-CB79	115	Circuit Breaker, 120v 40a	100	\$ 6.95	\$ 695.00	\$ 3,082.80

Converting to 2NF

Second Normal Form

- Definition:
 - The data model must be in 1NF AND. *important*
 - No partial functional dependencies can exist. *3*
- Rule:
 - Move each partially FD non-key column into its own new table.
- How to apply the rule:
 - For each partial dependency:
 - Move all partially FD columns into a new table.
 - Copy the determinant into the new table.
 - Make the determinant of the partial dependency:
 - The PK for the new table
 - The FK to the existing table

Purchase Order

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Vname	VAddr1	VAddr2	VCity	VState	VPostalCode	PONumber	PODate	VNumber	POShipDate	VItemNum	ItemNum	Descr	Qty	Price	Ext	POTotal
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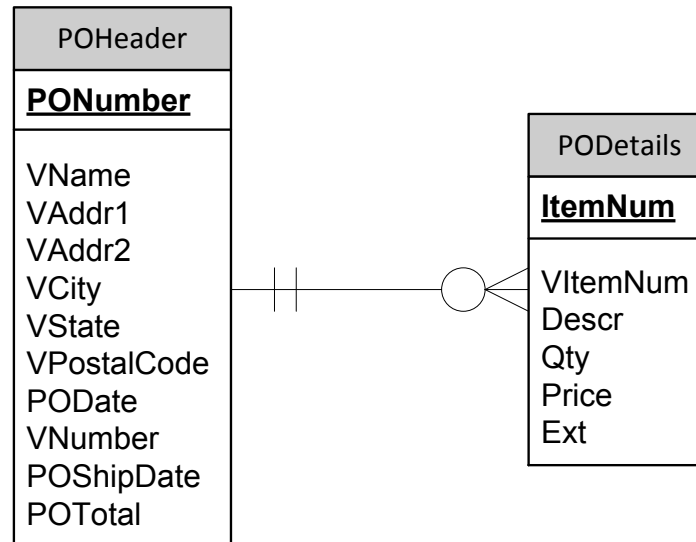
Vname	US Electrical Controls	US Electrical Controls	US Electrical Controls	US Electrical Controls
VAddr1	14878 Freemont Ave	14878 Freemont Ave	14878 Freemont Ave	14878 Freemont Ave
VAddr2	Suite 1800	Suite 1800	Suite 1800	Suite 1800
VCity	St Louis	St Louis	St Louis	St Louis
VState	MO	MO	MO	MO
VPostalCode	63127-5588	63127-5588	63127-5588	63127-5588
PONumber	100001	100001	100001	100001
PODate	1/14/2005	1/14/2005	1/14/2005	1/14/2005
VNumber	1007	1007	1007	1007
POShipDate	1/29/2005	1/29/2005	1/29/2005	1/29/2005
VItemNum	240-100-SW284	240-100-SW184	240-50-SW236	120-40-CB79
ItemNum	102	105	112	115
Descr	Switch, DPDT 240v 100a	Switch, SPDT 240v 100a	Switch, DPDT 240v 50a	Circuit Breaker, 120v 40a
Qty	50	100	80	100
Price	\$ 14.96	\$ 9.47	\$ 8.66	\$ 6.95
Ext	\$ 748.00	\$ 947.00	\$ 692.80	\$ 695.00
POTotal	\$ 3,082.80	\$ 3,082.80	\$ 3,082.80	\$ 3,082.80

Vname	US Electrical Controls	US Electrical Controls	US Electrical Controls	US Electrical Controls
VAddr1	14878 Freemont Ave	14878 Freemont Ave	14878 Freemont Ave	14878 Freemont Ave
VAddr2	Suite 1800	Suite 1800	Suite 1800	Suite 1800
VCity	St Louis	St Louis	St Louis	St Louis
VState	MO	MO	MO	MO
VPostalCode	63127-5588	63127-5588	63127-5588	63127-5588
PONumber	100001	100001	100001	100001
PODate	1/14/2005	1/14/2005	1/14/2005	1/14/2005
VNumber	1007	1007	1007	1007
POShipDate	1/29/2005	1/29/2005	1/29/2005	1/29/2005
VItemNum	240-100-SW284	240-100-SW184	240-50-SW236	120-40-CB79
ItemNum	102	105	112	115
Descr	Switch, DPDT 240v 100a	Switch, SPDT 240v 100a	Switch, DPDT 240v 50a	Circuit Breaker, 120v 40a
Qty	50	100	80	100
Price	\$ 14.96	\$ 9.47	\$ 8.66	\$ 6.95
Ext	\$ 748.00	\$ 947.00	\$ 692.80	\$ 695.00
POTotal	\$ 3,082.80	\$ 3,082.80	\$ 3,082.80	\$ 3,082.80

Purchase Order Header

Vname	US Electrical Controls
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VAddr2	Suite 1800
VCity	St Louis
VState	MO
VPostalCode	63127-5588
PONumber	100001
PODate	1/14/2005
VNumber	1007
POShipDate	1/29/2005
POTotal	\$ 3,082.80

Creates two new relations with new candidate keys



Purchase Order Details

VItemNum	240-100-SW284	240-100-SW184	240-50-SW236	120-40-CB79
ItemNum	102	105	112	115
Descr	Switch, DPDT 240v 100a	Switch, SPDT 240v 100a	Switch, DPDT 240v 50a	Circuit Breaker, 120v 40a
Qty	50	100	80	100
Price	\$ 14.96	\$ 9.47	\$ 8.66	\$ 6.95
Ext	\$ 748.00	\$ 947.00	\$ 692.80	\$ 695.00

Converting to 3NF

Third Normal Form

- Definition:
 - The data model must be in 2NF AND.
 - No transitive functional dependencies can exist.
- Rule:
 - Move each transitive FD non-key column into its own new table.
 - How to apply the rule:
 - For each transitive dependency:
 - Move all transitive FD columns into a new table.
 - Copy the determinant column into the new table.
 - Make the determinant of the transitive dependency:
 - » The PK for the new table
 - » The FK for the original table

Purchase Order

Vname	US Electrical Controls
VAddr1	14878 Freemont Ave
VAddr2	Suite 1800
VCity	St Louis
VState	MO
VPostalCode	63127-5588
PONumber	100001
PODate	1/14/2005
VNumber	1007
POShipDate	1/29/2005
POTotal	\$ 3,082.80



Purchase Order Header (now with more data!)

Vname	US Electrical Controls	American Electric	US Electrical Controls
VAddr1	14878 Freemont Ave	404 Notfound Rd	14878 Freemont Ave
VAddr2	Suite 1800		Suite 1800
VCity	St Louis	Pittsburgh	St Louis
VState	MO	PA	MO
VPostalCode	63127-5588	15201	63127-5588
PONumber	100001	100002	100003
PODate	1/14/2005	2/1/2005	3/1/2005
VNumber	1007	2089	1007
POShipDate	1/29/2005	2/28/2005	3/20/2005
POTotal	\$ 3,082.80	\$ 2,980.50	\$ 2,746.30

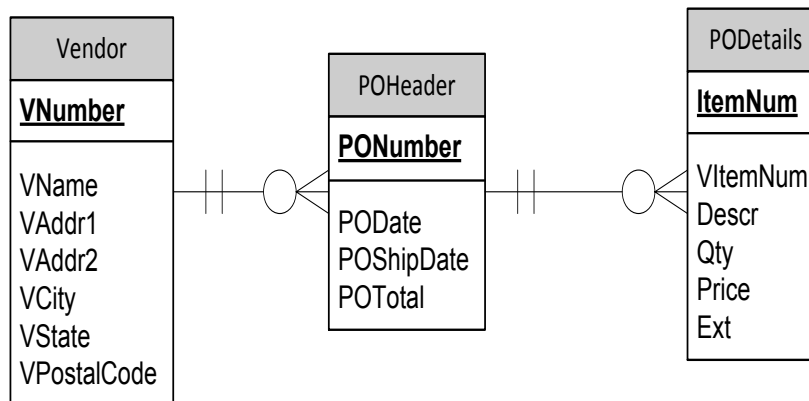
Purchase Order

Vname	US Electrical Controls
VAddr1	14878 Freemont Ave
VAddr2	Suite 1800
VCity	St Louis
VState	MO
VPostalCode	63127-5588
PONumber	100001
PODate	1/14/2005
VNumber	1007
POShipDate	1/29/2005
POTotal	\$ 3,082.80



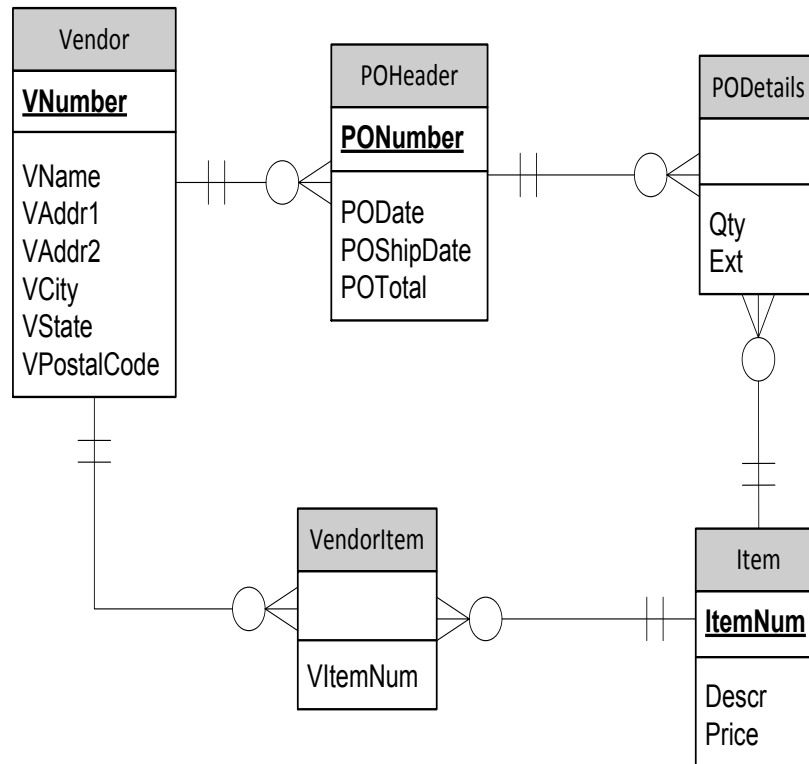
Purchase Order Header (now with more data!)

Vname	US Electrical Controls	American Electric	US Electrical Controls
VAddr1	14878 Freemont Ave	404 Notfound Rd	14878 Freemont Ave
VAddr2	Suite 1800		Suite 1800
VCity	St Louis	Pittsburgh	St Louis
VState	MO	PA	MO
VPostalCode	63127-5588	15201	63127-5588
PONumber	100001	100002	100003
PODate	1/14/2005	2/1/2005	3/1/2005
VNumber	1007	2089	1007
POShipDate	1/29/2005	2/28/2005	3/20/2005
POTotal	\$ 3,082.80	\$ 2,980.50	\$ 2,746.30



Purchase Order Details

VItemNum	240-100-SW184	240-50-SW236	120-40-CB79
ItemNum	105	112	115
Descr	Switch, SPDT 240v 100a	Switch, DPDT 240v 50a	Circuit Breaker, 120v 40a
Qty	100	80	100
Price	\$ 9.47	\$ 8.66	\$ 6.95
Ext	\$ 947.00	\$ 692.80	\$ 695.00

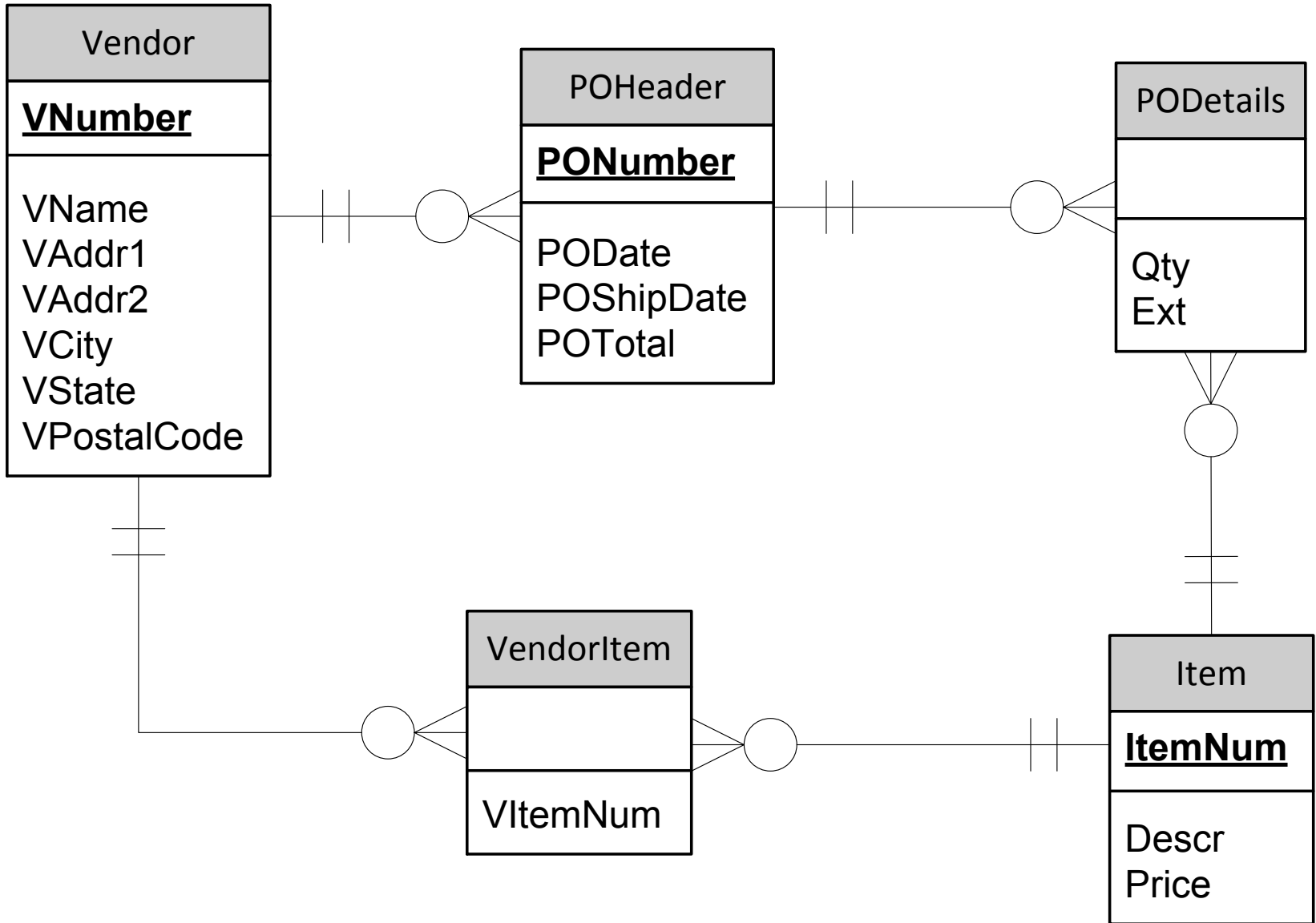


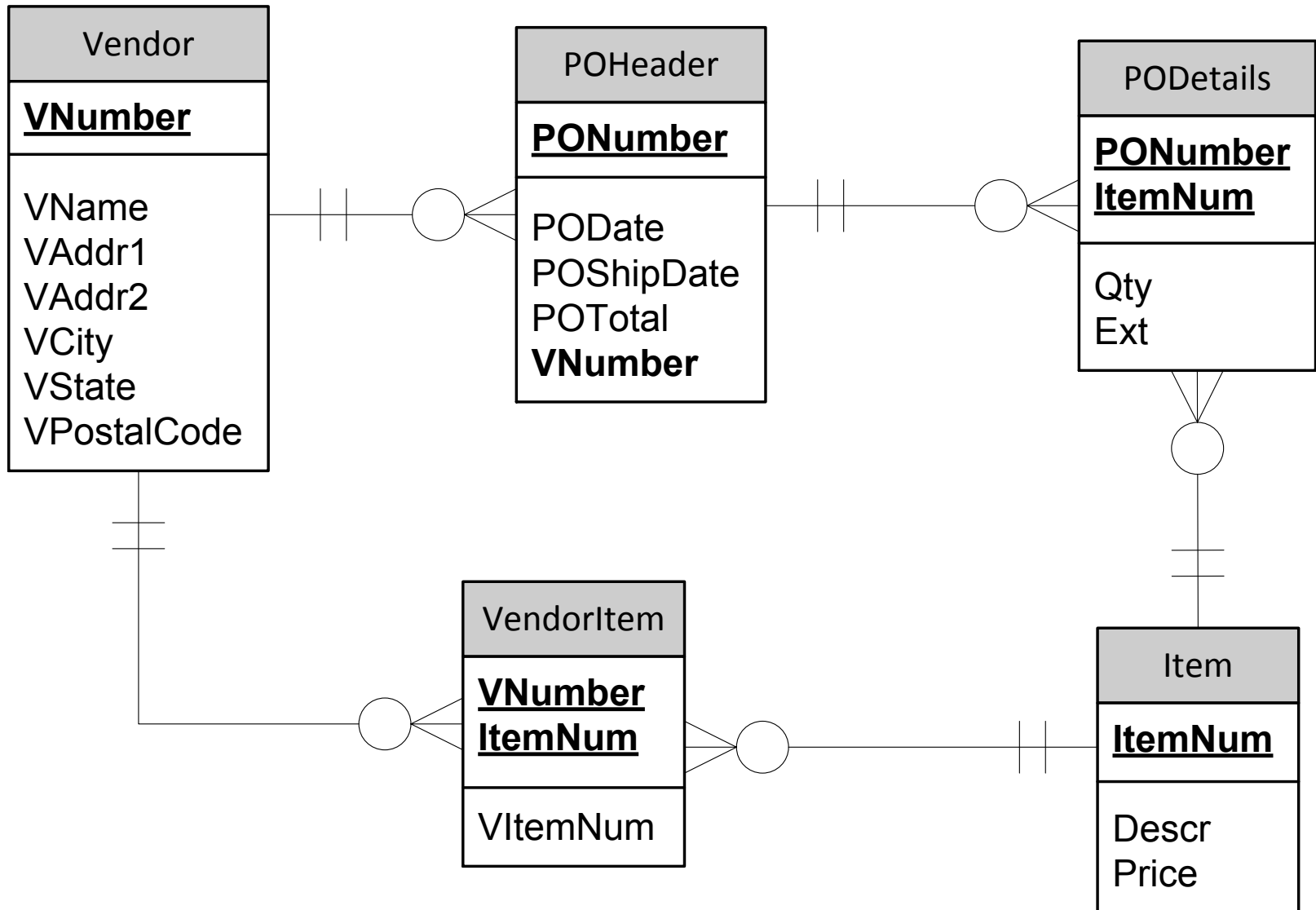


Foreign Keys

Foreign Keys

- An attribute in a relation that serves as primary key in another relation
- The link between related tables





Beyond 3NF

Normal Forms Beyond Third

- Elementary Key Normal Form
 - Extension of 3NF where there is more than one overlapping composite key.
- Boyce-Codd Normal Form
 - Only one possible primary key exists in a relation. All functional dependencies have been removed.
- Fourth Normal Form
 - Multivalued dependencies are removed.
- Fifth Normal Form
 - All remaining anomalies removed.



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