Introduction

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Agenda:

- The physical design process and environments
- Developing standards
- Physical design guidelines
- Demo: star schema generation from the detailed worksheet
- Demo: validating your star schema with data
- The test environment

So, Where Are We?

We covered:

- Dimensional modeling

We learned how to:

- Design dimensional models for relational databases

Detailed design

We'll cover

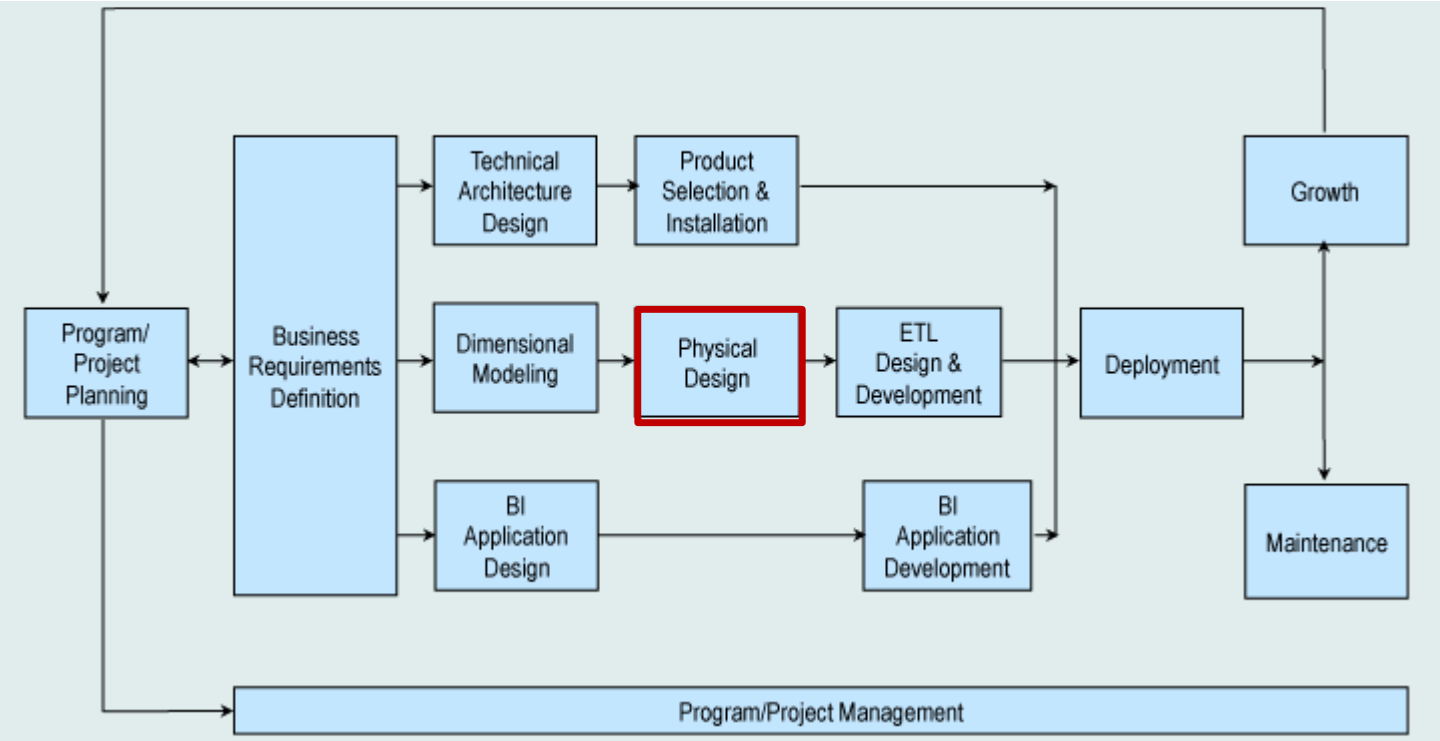
- ROLAP implementation of dimensional models

We'll learn how to

- Implement dimensional models in relational databases

Implementation

Kimball Lifecycle



The Goal: Detailed Design to ROLAP Implementation

Detailed Design

	A	B	J	K	L	M	N	O	P
1	Table Name	DimCustomer							
2	Table Type	Dimension							
3	Display Name	Customer							
4	Database Schema								
5	Table Description	Customers dimension							
6	Comment	comes from customers table in northwind							
7	Biz Filter Logic								
8	Size	one for each customer							
9	Generate Script?	N							
10									
11			Target						
12	Column Name	Display Name	Datatype	Size	Precision	Key?	FK To	NULL?	Default Value
13	CustomerKey	CustomerKey	int			PK ID		N	
	CustomerID	CustomerID	nvarchar	5				N	
14									
15	CompanyName	CompanyName	nvarchar	40				N	
16	ContactName	ContactName	nvarchar	30				N	
17	ContactTitle	ContactTitle	nvarchar	30				N	
18	CustomerCountry	CustomerCountry	nvarchar	15				N	
19	CustomerRegion	CustomerRegion	nvarchar	15				N	N/A'
20	CustomerCity	CustomerCity	nvarchar	15				N	
21	CustomerPostalCode	CustomerPostalCode	nvarchar	10				N	
	RowIsCurrent	Row Is Current	bit					N	TRUE
22									
	RowStartDate	Row Start Date	datetime					N	
23									
	RowEndDate	Row End Date	datetime					N	12/31/9999
24									
25	RowChangeReason	Row Change Reason	nvarchar	200				Y	
26	InsertAuditKey	InsertAuditKey	int			FK	DimAudit.AuditKey	N	
	UpdateAuditKey	UpdateAuditKey	int			FK	DimAudit.AuditKey	N	
27									

```
51 create table DimCustomer
52 (
53     CustomerKey int identity not null,
54     [Name] varchar(50) not null,
55     [City] varchar(20) not null,
56     [State] char(2) not null,
57     [ZipCode] char(5) not null,
58     constraint pkCustomerKey primary key (CustomerKey)
59 );
```

ROLAP

Today's Agenda:

Describe the process of implementing dimensional model designs in a relational database (ROLAP).

Discuss approaches to implementation.

Walk through an implementation together using a case study, so you can see this in action!

What Is Physical Design?

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What Exactly Is Physical Design?

- **Physical design** is the creation of actual artifacts as part of the design.
- In **data warehousing** the physical design is commonly implemented in a RDBMS.
- In the **Kimball enterprise bus technical architecture**, we implement **star schemas** with conformed dimensions.
- Physical design tasks include:
  - Making tables, keys, and constraints
  - Setting up schemas, synonyms, and views
  - Measuring and adjusting for performance
- Physical design is split up into the **internal (not user-facing)** and **external (user-facing)** models.

Internal vs. External Models

External Model

- User's view of the implementation
- Views, synonyms, natural/ business keys

Internal Model

- The actual implementation itself
- Tables, keys (PK/FK), triggers, check constraints

Conceptual to Physical: The Big Picture

	Conceptual Design	Logical Design	Physical Design
Task:	Identify functional requirements	Dimensional modeling	Create actual database objects
Tools used:	High-level dimensional modeling worksheet	Detailed-level dimensional modeling worksheet	SQL: database tables, keys, constraints, and views
Deliverable	Bus matrix	Dimensional models	ROLAP star schema

Development, Test, and Production Environments

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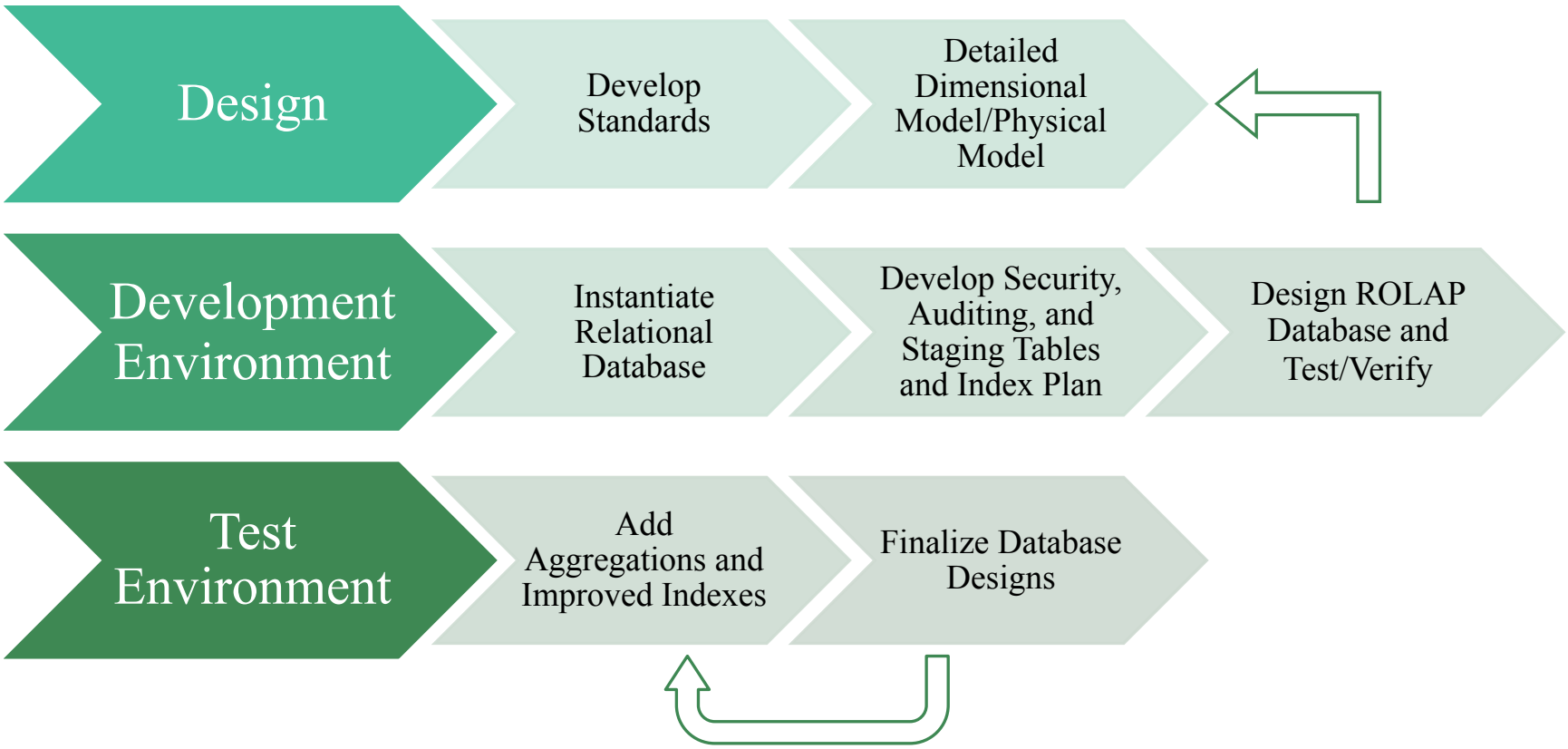
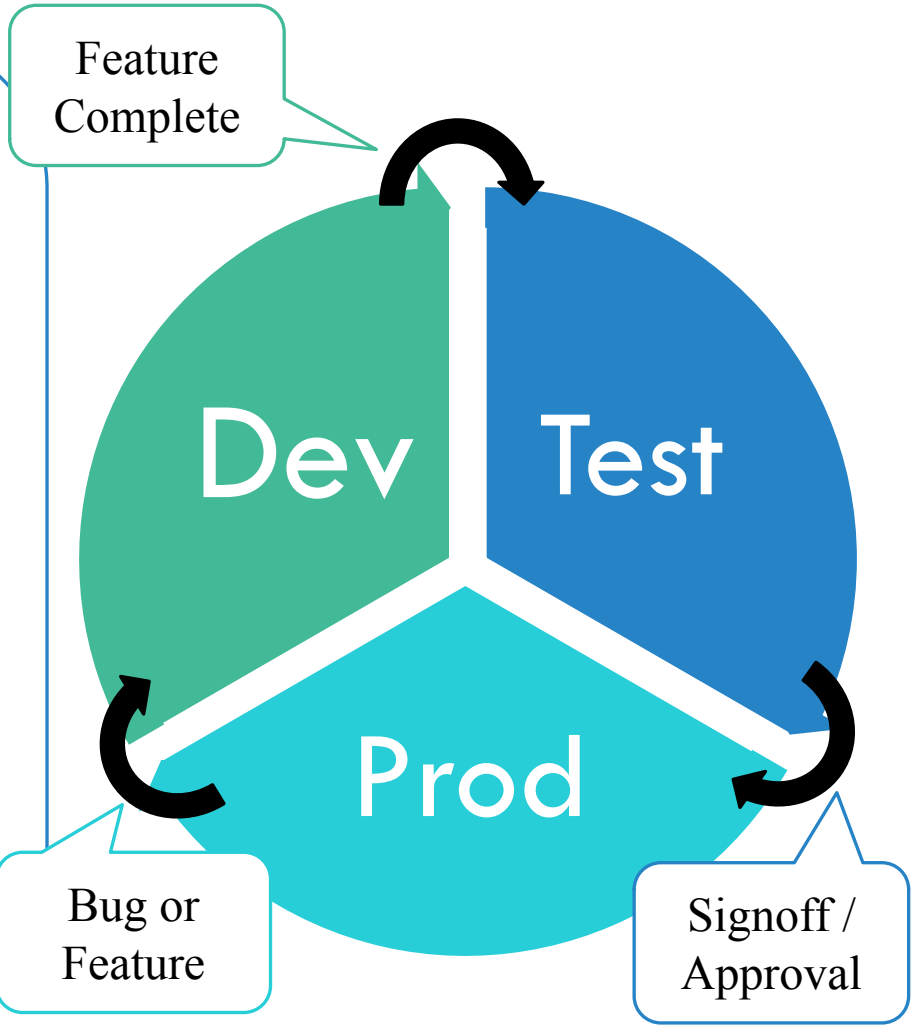
The Physical Design Process at a Glance



A Word About Environments

- **Development:**
  - Isolated to the developers only
  - Used for building things
  - Can use subsets of data
- **Test:**
  - Open to end users
  - As close to the production environment as possible
  - Measure performance here
- **Production:**
  - The actual system
  - Never make changes here



Developing Standards

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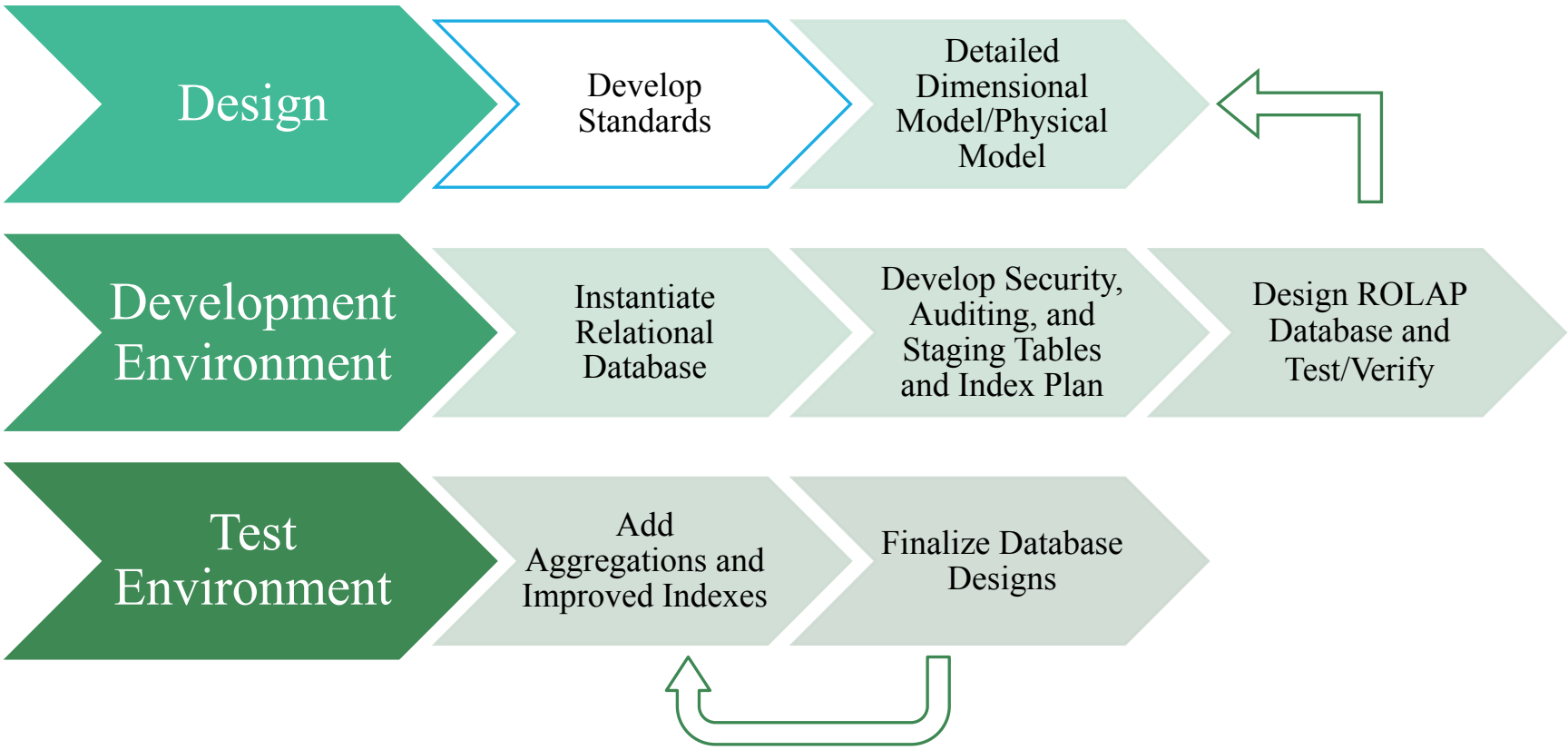
Developing Standards



Standards?

- Standards get everyone on the same page.
- Developers follow the standards, which leads to consistency.
- Business users are aware of the standards and require less training.
- Standards are challenging to enforce in large teams. It is best to put someone in charge of making sure the project teams adhere to standards.

Naming Conventions

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Naming Conventions

- Follow your organization's naming conventions.
- If you don't have any, establish them first!
- Consistency is key here!

How do you name dimensions?

- ✓ `Customer_Dim`
- ✓ `DimCustomer`
- ✓ `dim_customer`
- ✓ `[Dim Customer]`

Naming Conventions

- Table and view prefixes:
  - Stage table → **Stg**
    - Example: StgFudgemartEmployeeTimesheets
  - Dimension → **Dim**
    - Example: DimCustomer
  - Fact → **Fact**
    - Example: Fact EmployeeTimesheets
- Dimension keys:
  - Ends with "Key" → Customer**Key.**
  - Don't use ID; that's a convention for OLTP sources.

Is It Time to Use an SCM? Yes.

SCM ➔ Source code management

- Git, Subversion, Mercurial, CVS

Time to get serious about an SCM, since you'll be:

- Generating/creating code
- Making **lots of changes**
- Collaborating with others concurrently

SCM tools allow you to record and track changes to your code and easily rollback versions and collaborate with others.

Schemas

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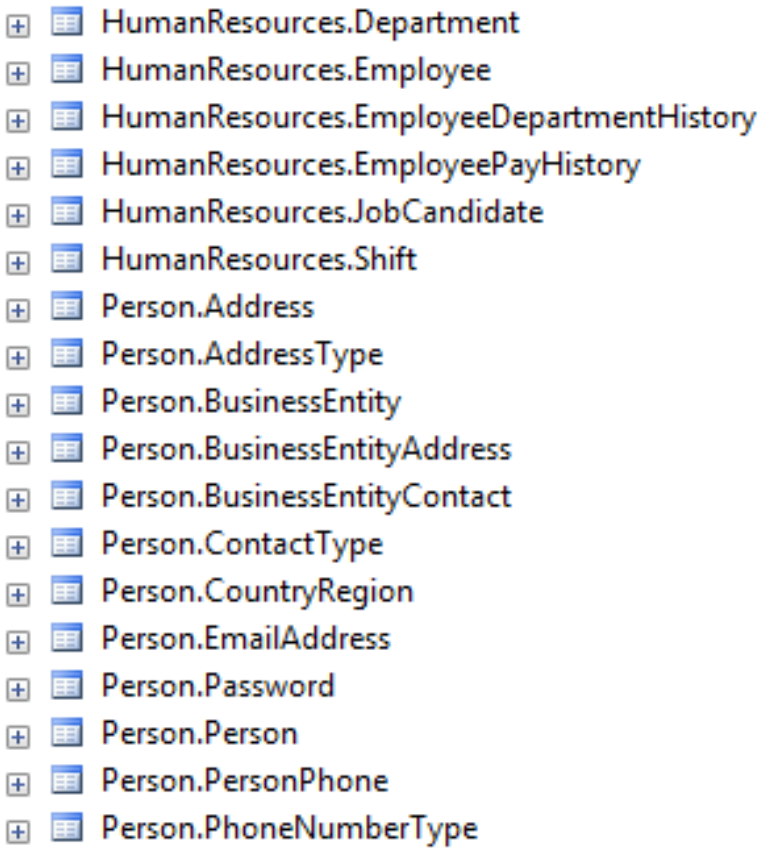
Schemas

- Schemas are **namespaces**, which facilitate the separation, management, and ownership of database objects.
- Objects are securable by schema.

```
CREATE SCHEMA name
```



Views and Synonyms

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Synonyms and Views

- Synonyms and views are logical abstractions of tables and SQL SELECT statements, respectively.
- For any table **directly accessible by an end user**, a view or synonym should be used. This helps us build the **external model**.
- This way you can change the underlying tables without affecting the **external dependencies** (reports, BI applications, etc.).

```
CREATE VIEW name AS …

CREATE SYNONYM name FOR …
```

Data Type Selection

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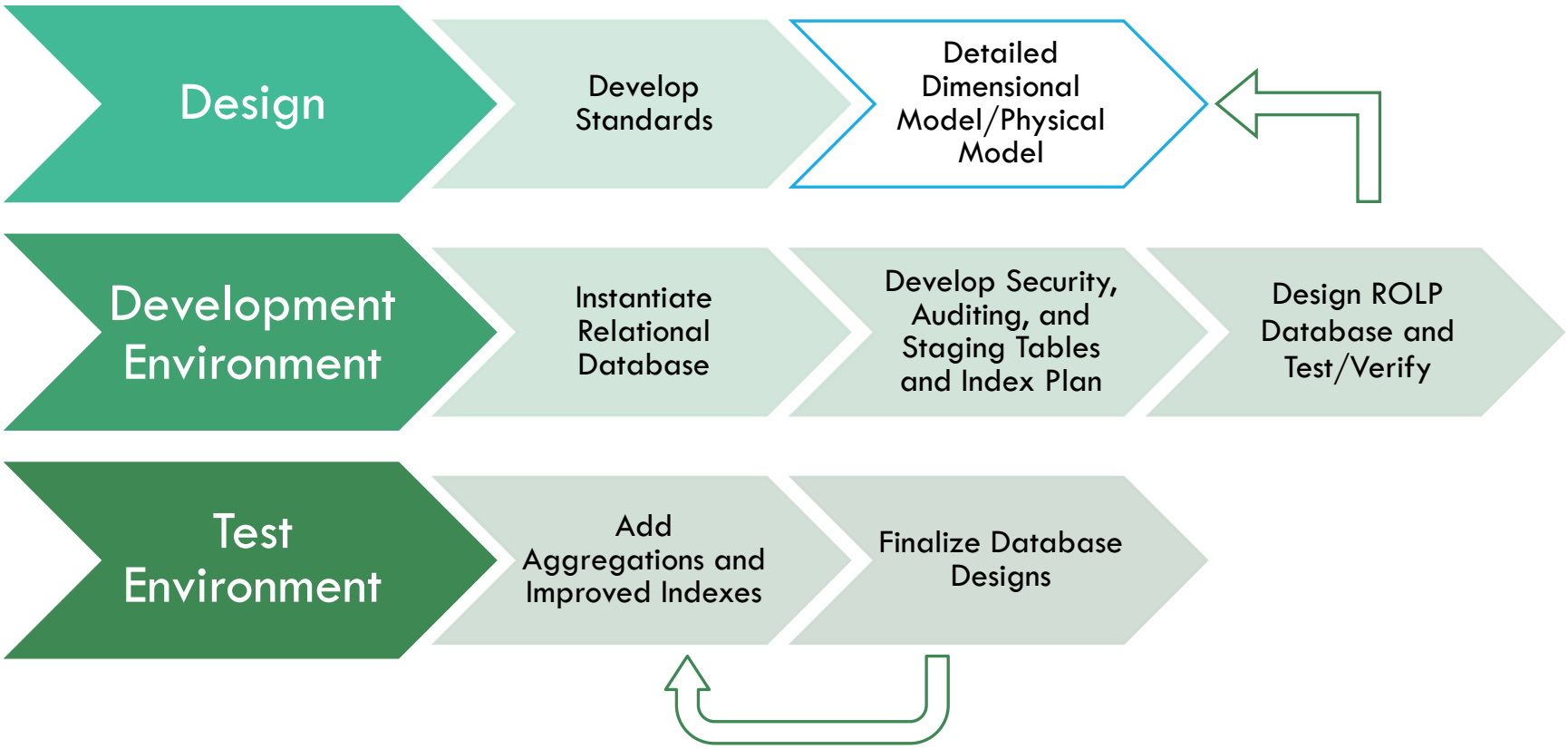
The Physical Model



Every Byte Counts in a Fact Table!!!

	Total bytes of data types	88 Bytes
X	Total number of rows	5 Billion
	Total amount of disk storage for this fact table	**440 GB**

Data Types

Data Type	Description	Storage
`smallint`	Integers -32K to +32K	2 bytes
`int`	Integers -2B to +2B	4 bytes
`bigint`	Integers $-9B^2$ to $+9B^2$	8 bytes
`decimal(p,s)`	Decimal values from -10^{38} to $+10^{38}$	5-17 bytes
`money`	Monetary values -900T to + 900T	8 bytes
`datetime`	Date/times from 1/1/1753 to 12/31/9999	8 bytes
`char(n)`	Fixed-character string specific charset	n bytes
`nchar(n)`	Fixed-character string Unicode charset	2n bytes
`varchar(n)`	Variable length string specific charset	2 + n bytes
`nvarchar(n)`	Variable length string Unicode charset	2 + 2n bytes

Saving Space With Types

- Don't use money or decimal when int will suffice.
  - Savings: 1 to 13 bytes
- Don't use nvarchar unless you require Unicode.
  - Savings: 4 bytes
- Don’t use char(1) for Yes/No; use bit.
  - Savings: 0 to 7 bytes (depending on the number of bit fields)
- Use smallint instead of int.
  - Savings: 4 bytes
- Use int YYYYMMDD for date instead of datetime.
  - Savings: 4 bytes

Primary and Foreign Keys

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Primary Keys

- Dimension tables should use **surrogate keys.**
- Fact tables should use **composite keys** made up of **dimension foreign keys** and **degenerate dimensions**.
- Surrogate keys can be used in the fact table, but they increase the table size and do not improve performance.
- Surrogate keys are **number sequences. Date surrogate** keys should be of the form YYYYMMDD.
- ***Every byte counts in your fact table!***

Foreign Keys

- **Foreign keys** are important. Don't devalue!
- FKs enforce **referential integrity** between the PK in the dimension table and the FK in the fact table.
- ***This prevents you from inserting invalid data into the fact table.***
- If you're concerned about the **performance impacts of constraint checking,** you can drop the FKs, insert the data, then reinstate the constraints with the `no-check` option.

Example: Primary and Foreign Keys

	CustomerKey	CustomerID	CompanyName	ContactName	ContactTitle	CustomerCountry	CustomerRegion	Custome
1	65	QUICK	QUICK-Stop	Horst Kloss	Accounting Manager	Germany	N/A	Cunewa
2	67	RATTC	Rattlesnake Canyon Grocery	Paula Wilson	Assistant Sales Representative	USA	NM	Albuque
3	50	LONEP	Lonesome Pine Restaurant	Fran Wilson	Sales Manager	USA	OR	Portland
4	88	WANDK	Die Wandernde Kuh	Rita Müller	Sales Representative	Germany	N/A	Stuttgar
5	60	PERIC	Pericles Comidas clásicas	Guillermo Fernández	Sales Representative	Mexico	N/A	México
6	16	CHOPS	Chop-suey Chinese	Yang Wang	Owner	Switzerland	N/A	Bern
7	64	QUEEN	Queen Cozinha	Lúcia Carvalho	Marketing Assistant	Brazil	SP	Sao Pau
8	43	LAMAI	La maison d'Asie	Annette Roulet	Sales Manager	France	N/A	Toulous
9	62	PRINI	Princesa Isabel Vinhos	Isabel de Castro	Sales Representative	Portugal	N/A	Lisboa
10	46	LEHMS	Lehmanns Marktstand	Renate Messner	Sales Representative	Germany	N/A	Frankfu

	ProductKey	OrderID	CustomerKey	EmployeeKey	OrderDateKey	ShippedDateKey	Quantity	ExtendedPriceAmount	DiscountAmount	SoldAmount
1	1	10285	65	1	19960820	19960826	45	648.0000	129.6000	518.4000
2	1	10294	67	3	19960830	19960905	18	259.2000	0.0000	259.2000
3	1	10317	50	5	19960930	19961010	20	288.0000	0.0000	288.0000
4	1	10348	88	3	19961107	19961115	15	216.0000	32.4000	183.6000
5	1	10354	60	7	19961114	19961120	12	172.8000	0.0000	172.8000
6	1	10370	16	5	19961203	19961227	15	216.0000	32.4000	183.6000
7	1	10406	64	6	19970107	19970113	10	144.0000	0.0000	144.0000
8	1	10413	43	2	19970114	19970116	24	345.6000	0.0000	345.6000
9	1	10477	62	4	19970317	19970325	15	216.0000	0.0000	216.0000
10	1	10522	46	3	19970430	19970506	40	720.0000	144.0000	576.0000

Nulls and Unknown Members

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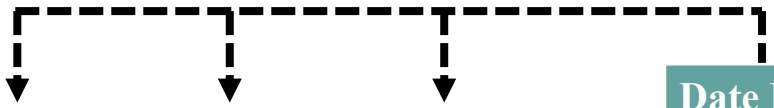
Best Practices for Nulls

- The **attributes** in your **dimension** tables should not have nulls.
- Attributes **without a value** (null) should be assigned a value. Why is it null?
  - Example: no e-mail address? ➔ "No E-mail"
- **Foreign keys** in the **fact** table should never be null; they should be assigned an **unknown member.**
- Nulls are okay for ***values*** in the fact tables. Null valued facts are not included in calculations.

Unknown Members

- We should not insert NULL into the FK of a fact table. We should use an unknown member instead!
- These are special coded values, which indicate why there is no value.
- Every dimension should have at least one unknown member.



Order ID	Order Date Key	Ship Date Key	Delivery Date Key
99001	20170401	20170403	20170412
99002	20170408	20170409	-3
99003	20170412	-2	-3
99004	20170415	-2	-3
9905	-1	-1	-1

Date Key	Date	Date Name
-3	0000-00-00	Not Delivered
-2	0000-00-00	Not Shipped
-1	0000-00-00	Unknown Date
20100101	2010-01-01	1/1/2010
20100102	2010-01-02	1/2/2010

Implementing Type 2 SCD Metadata

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Type 2 SCD Metadata

- Type 2 preserves history.
- These columns should be added to assist with tracking but not displayed to the end user.
- Perfect use case for a view to separate the table from the user-facing columns.
- Add these columns:
  - RowIsCurrent (Y/N) → Is this the current row?
  - RowStartDate (datetime) → Start date of valid row
  - RowEndDate (datetime) → End date of valid row
  - RowChangeReason (text) → Explain why row changed

The Development Environment

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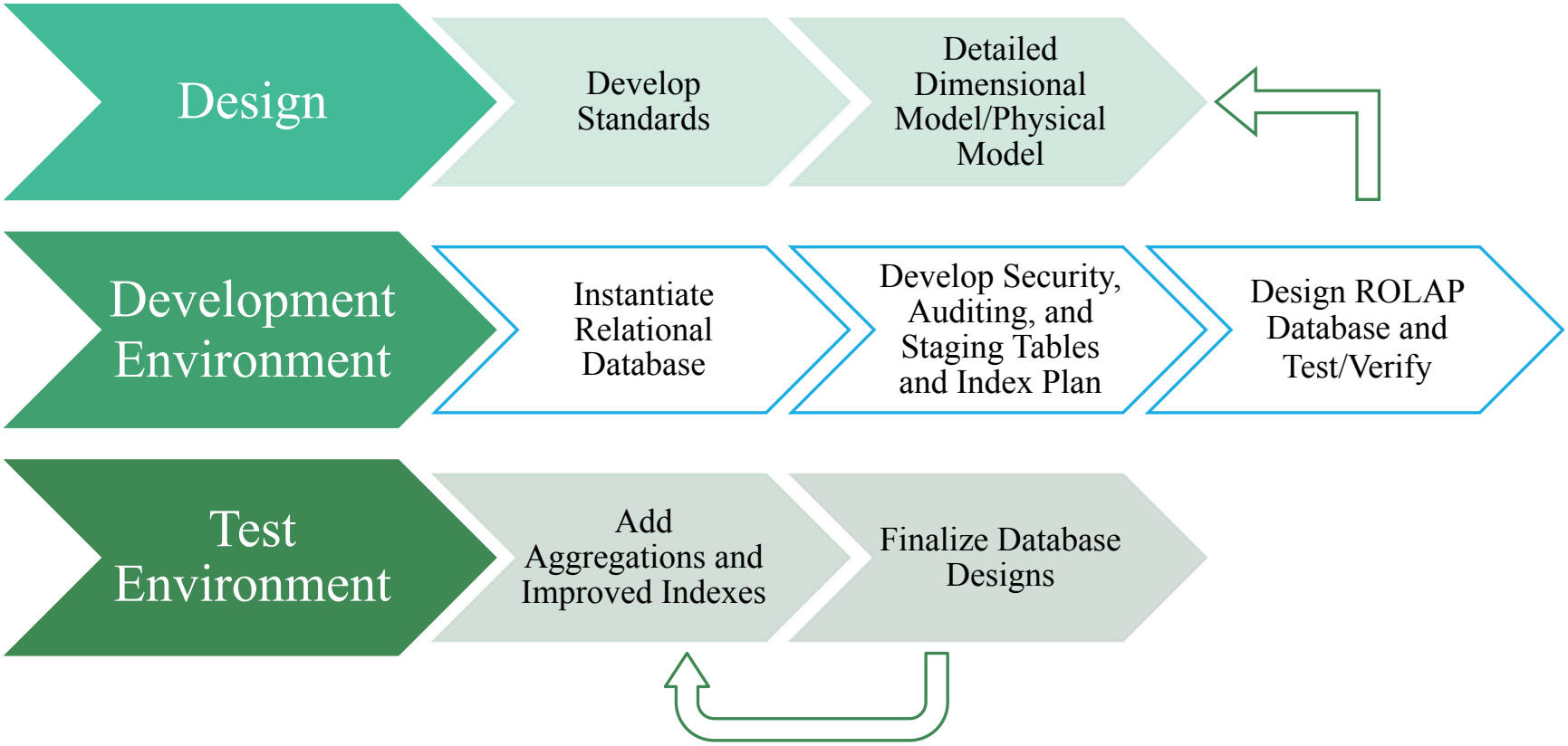
Build Your Development Environment



Instantiate the ROLAP Database

- You'll need this **before** you can develop the ETL process.
- You don't need to focus on **performance** at this point because you don't know the **bottlenecks**.
- The Development environment should be separate from the test environment.
- Update your detailed modeling worksheet as you make changed to keep your schema consistent with the documentation.

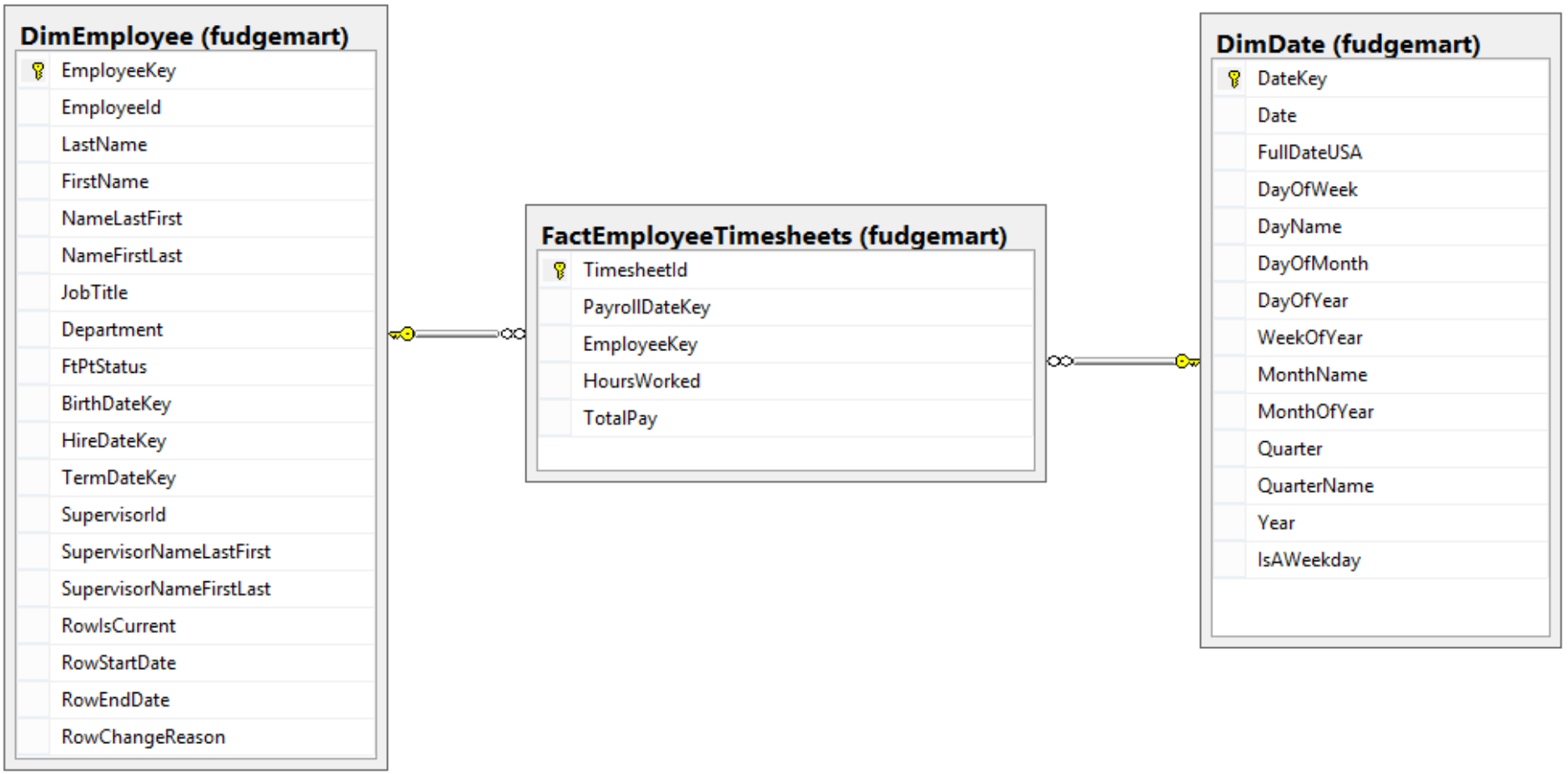
Our Case Study:
Fudgemart Employee Time Sheets

Business Process Name	Fact Table	Fact Grain Type	Granularity	Facts	Payroll Date	Employee
Employee Timesheets	FactEmployeeTimesheets	Transation	One row per timesheet entry (employee + date)	Hour Worked, Total Pay	X	X

We will:

- ✓Implement the ROLAP Schema
- ✓Load with data to test / verify the model

The ROLAP Star Schema



Overview of the Process

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Initial ETL Load for Model Validation

Doing initial with SQL: Why?

1. Stage data.
   - Address data-sizing issues.
   - Take samples/subsets.
2. Transform and load into model.
   - Understand the required manipulations from source to target.
   - You'll be better prepared for the actual ETL.
3. Test and verify the model.
   - Fact grain makes sense?
   - Facts are additive?
   - Default members in place of null?
   - Dimensions attributes have values?

Best Practices for Data Extraction to Stage

- Always stage your data "as is" to avoid a dependency on the source systems.
- This is important during development as live data are always changing, and we want to freeze data to a point in time during initial development.
- You do not want your stage data in the same database or schema as your data warehouse. Helps keep the models "tidy." **You should be working in a development environment.**

Dataset Too Big for Your Development Environment?

Create a subset!

- Random sample of transactions.
  - Get 10% of the 1,000,000 rows.
- Filter on a specific time.
  - One year rather than all 10 years.
- Random sample from a dimension.
  - Select 10 random customers.
- Filter on a dimension.
  - Only specific customers or products
- **When you move to test, you must use ALL the data!**

The Test Environment

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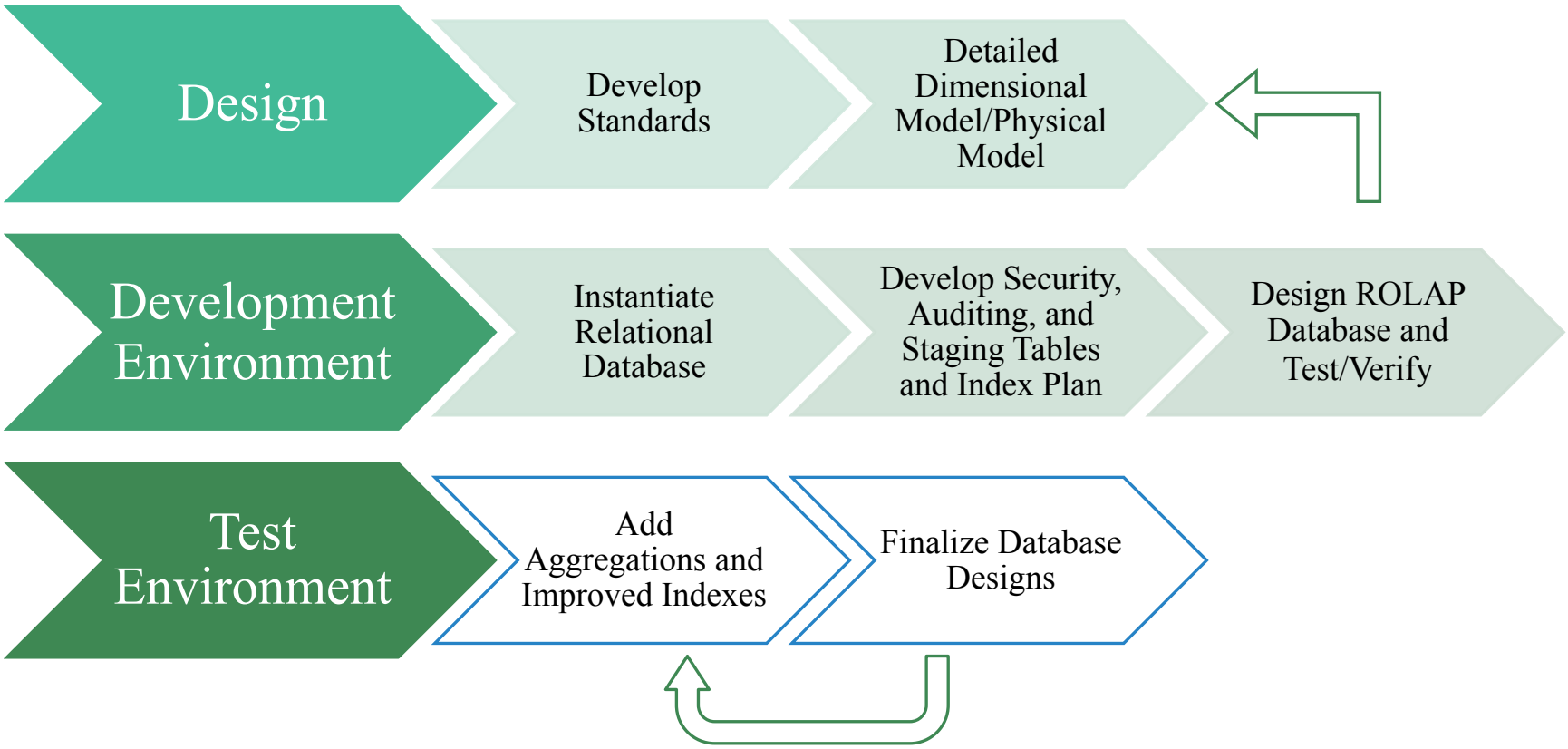
The Test Environment



Test Environment

- Must be a networked environment so users can access it.
- End users and key stakeholders are doing the testing.
- Same dataset as production environment (or as close to it as feasible).
- Typically just an additional database instance on the production server but can be a separate installation.
- Is loaded with only the data needed for testing. When testing is complete, the environment is reset.
- Key tasks: **monitor usage** and **adjust system performance.**

Test Environment Credo

"Your test environment contains ONLY what you're testing, but ALL of what you're testing."

Example:

- We are testing Fudgemart employee timesheets, so ONLY need that star schema, but we need ALL the data loaded into it.
- It's about performance!

Performance

Ways to Measure

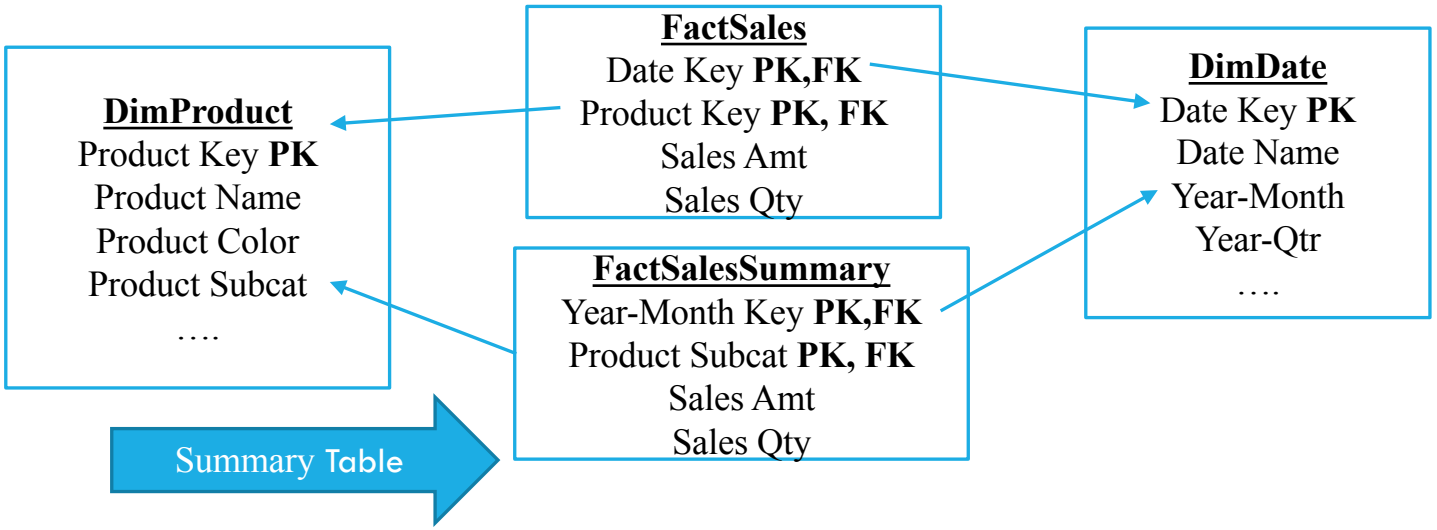
- Query execution plans
  - What has run?
- Query execution times
  - How long does it take?

Ways to Improve

1. Summary tables
2. Partitioning
3. Indexes

Build Summary Tables

- Number-one way to improve performance.
- Aggregate popular roll-up data.
- Monitor queries to find out what's popular.
- Created through the ETL process.



Materialized Views

- An SQL view that saves a copy of the query output.
- This offers a performance boost because the materialized view output acts as a table.
- SQL server offers indexed views, which function similarly.
- Alternative to summary tables, which must be created each time.

Partitioning

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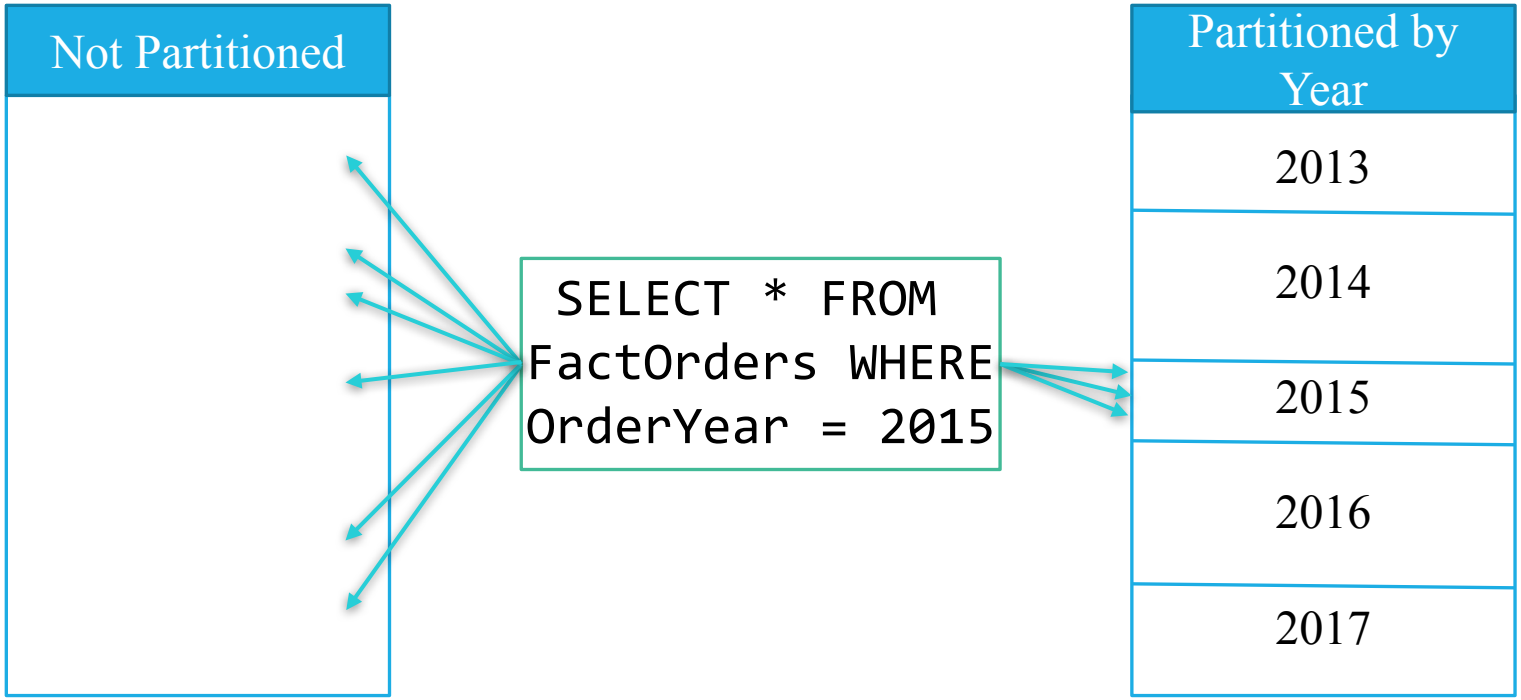
Partitioning

- Number-two way to improve performance.
- Most data in fact tables are inserted in chronological order.
- It makes sense to physically organize the fact table by date.



Indexing and Clustered Index

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Index

- Number-three way to improve performance.
- **Index** improves search of a table by creating an internal structure with keys built from one or more columns. You can have multiple indexes per table.
- **Clustered index** is an index on the table itself. It determines the order the data is written to the table; thus there can only be one.

DimProduct		
ProdKey	Name	Department
1	Hammer	Hardware
2	T-Shirt	Clothing
3	Wrench	Hardware
4	Socks	Clothing
5	TV Set	Electronics
6	Shoes	Clothing
7	Drill	Hardware

Department Index	
Department	IDs
Clothing	2,4,6
Electronics	5
Hardware	1,3,7

As data change, the index must be rebuilt, hence the negative impact on write performance.

Indexing Dimension and Fact Tables

- If your DBMS supports **bitmapped indexes**, add them to your dimension tables on attributes involved in **row filters**.
- For fact tables, follow the index plan optimizer of your DBMS.