

Let's Dive Into SQL Server I/O To Improve T-SQL Performance

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- Microsoft MVP (2017-2018)



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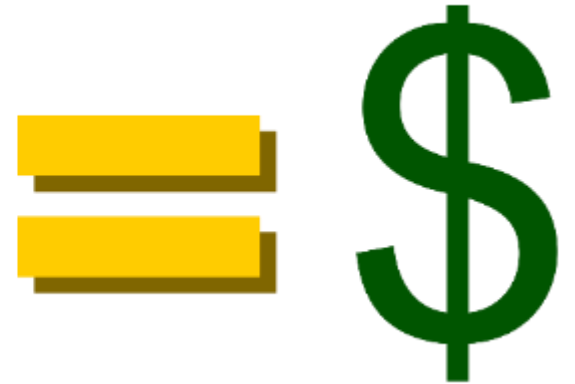
Setting the Stage



Pack It Up!



Are We There Yet?



Have You Ever...

- That query only returns 5 records, why is it slow?
- That query typically runs in 5 seconds, but it's hanging now
- Wondered what your query is really doing behind the scenes?

Today's Agenda

1. Internals: Query Lifecycle
2. Internals: Data Structures
3. Internals: Navigating
Heaps & Indexes
4. T-SQL & I/O Scenarios

Goal:

To explore SQL Server I/O, to better understand query performance issues

Session Level:

- 200 - 300
- Splash of 400

Internals: Query Lifecycle

I Like Analogies



T-SQL Query



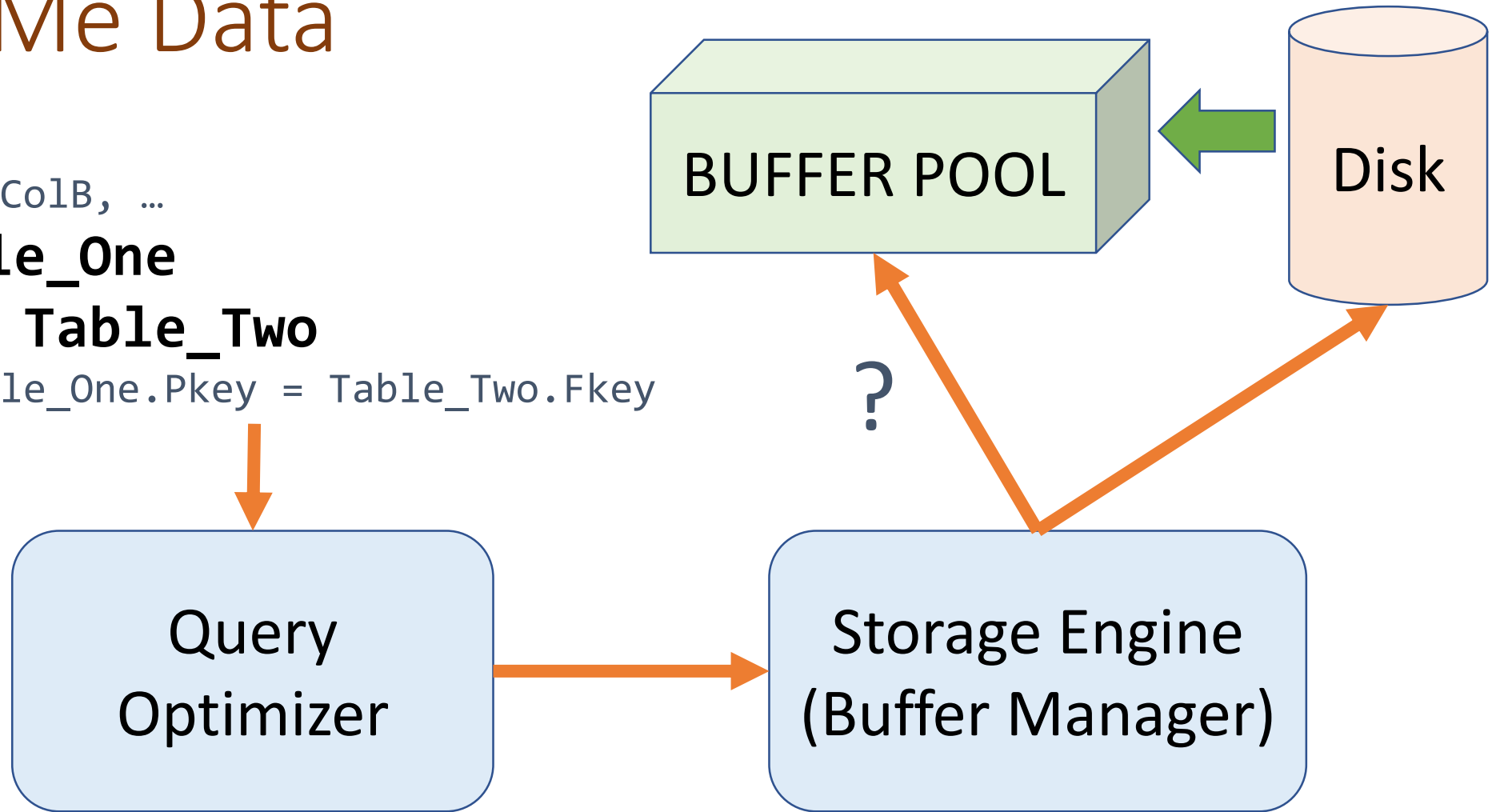
Query
Optimizer



Storage
Engine

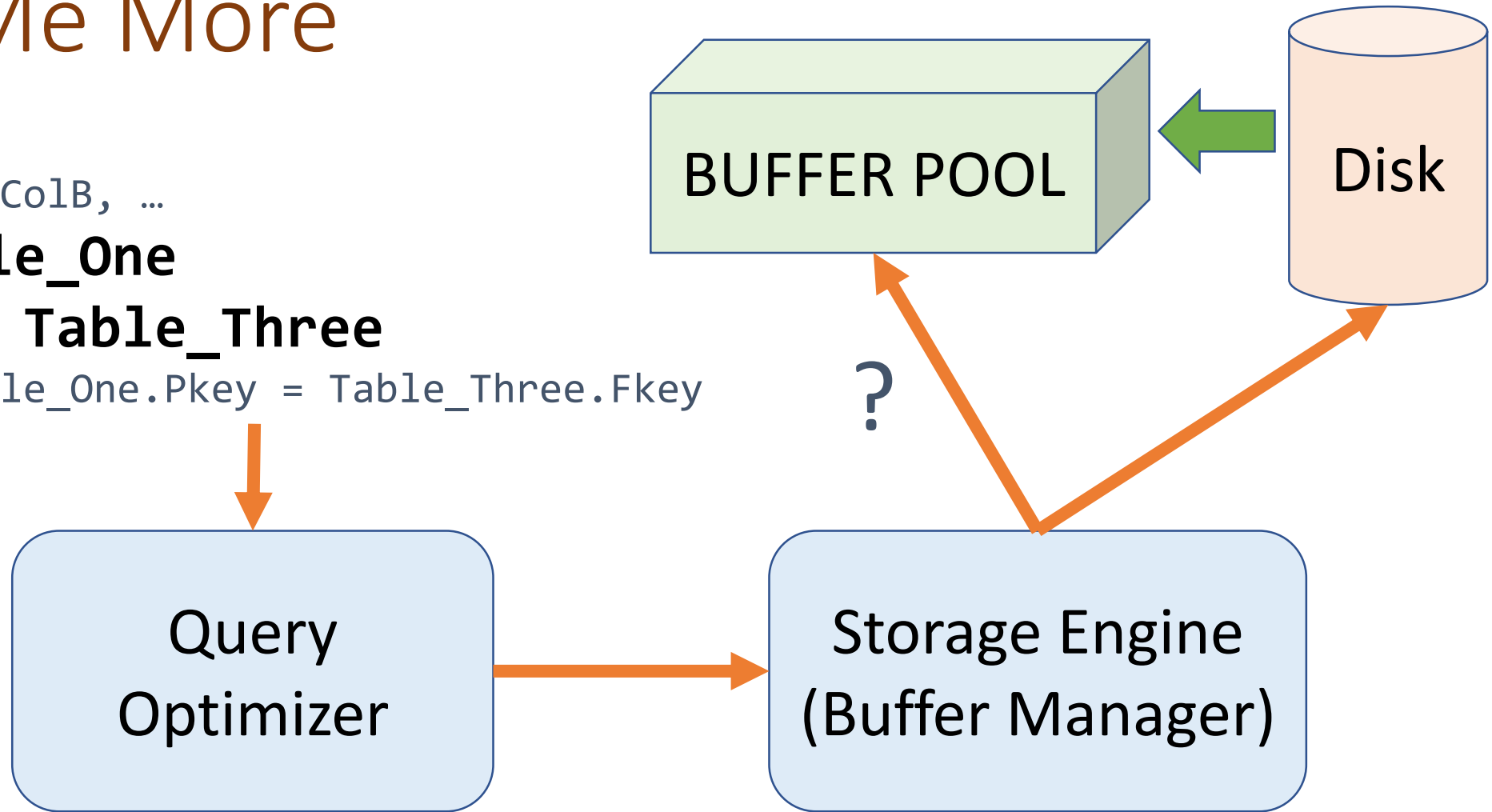
Give Me Data

```
SELECT  
    ColA, ColB, ...  
FROM Table_One  
INNER JOIN Table_Two  
    ON Table_One.Pkey = Table_Two.Fkey
```



Get Me More

```
SELECT  
    ColA, ColB, ...  
FROM Table_One  
INNER JOIN Table_Three  
    ON Table_One.Pkey = Table_Three.Fkey
```



Key Takeaways

Disk I/O is slower than Buffer Pool I/O

All work is executed against data pages in the Buffer Pool

Internals: Data Structures

Just Get Me One Record

```
SELECT TOP 1  
    ColA, ColB  
FROM Table_One
```

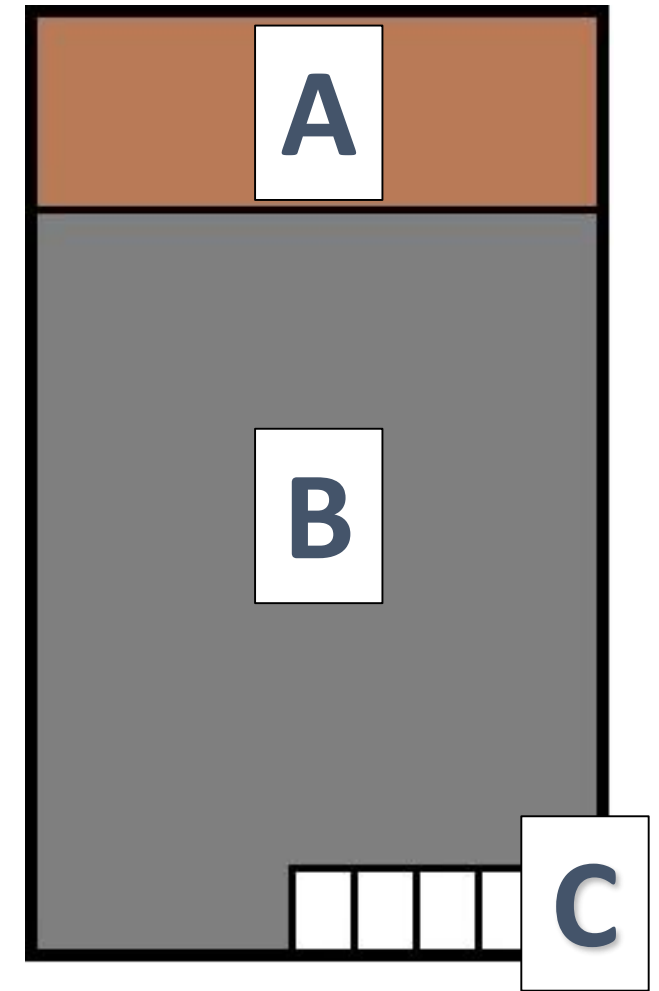
?

Data Page: Overview

Comprised of 3 components:

- A. Page Header: 96 bytes
- B. Data Records
- C. Record or Slot Array:
2 bytes per record

All Pages have a Fixed Size of 8KB or 8,192 bytes

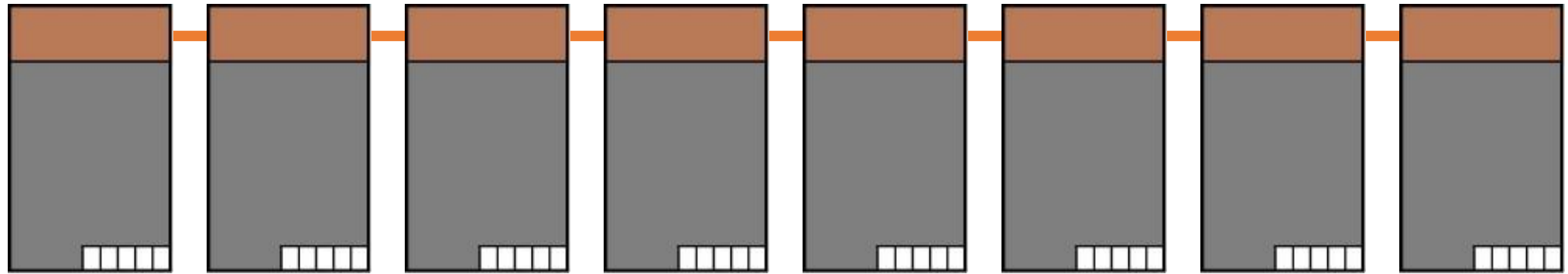


A collection of data pages is...

```
CREATE TABLE MyTable (  
    MyTableID INT,  
    ColumnOne VARCHAR(15),  
    DateCreated DATE  
);
```

?

Heap

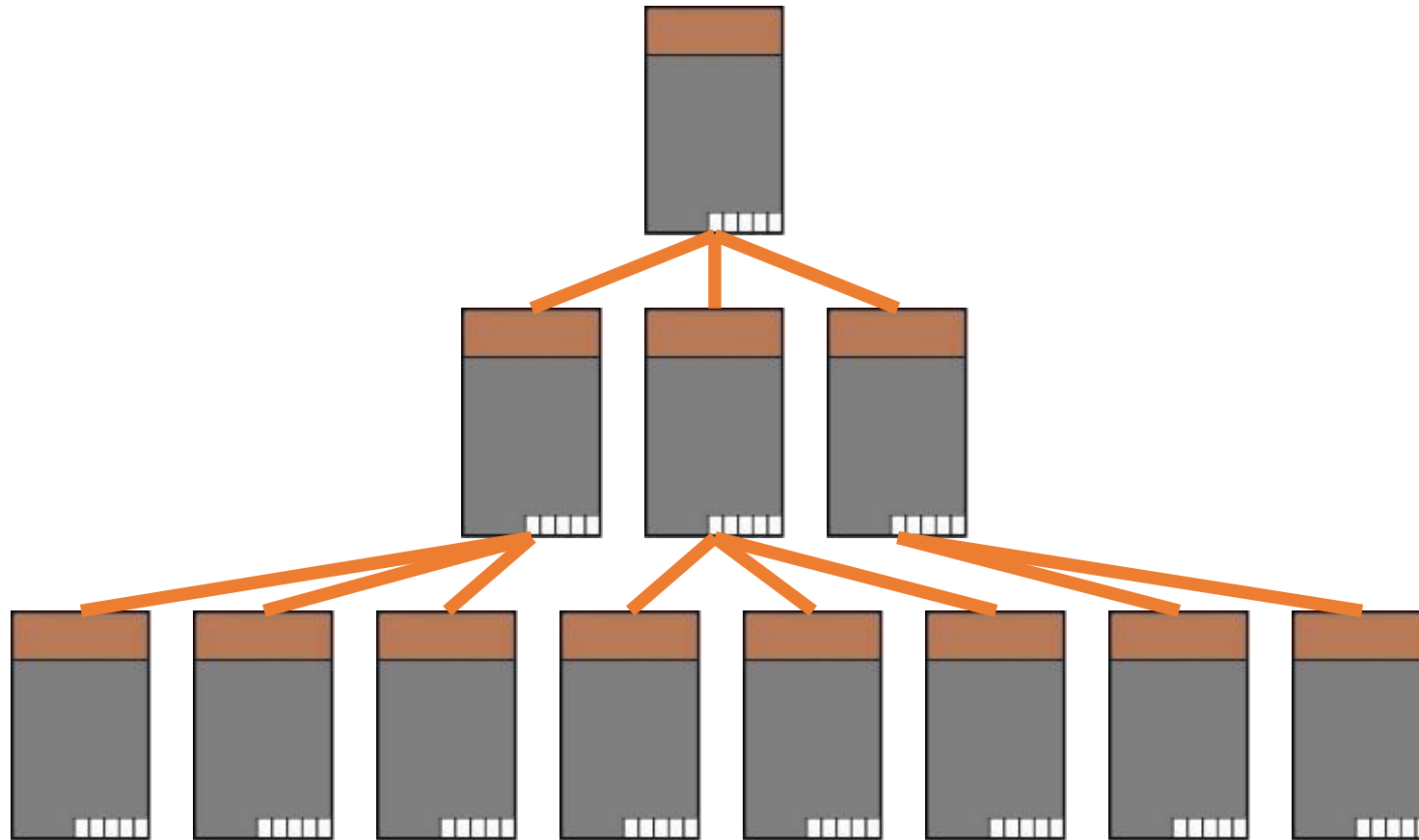


I Want Order!

```
CREATE CLUSTERED INDEX  
    CK_MyTable  
ON MyTable (  
    MyTableID INT  
);
```

?

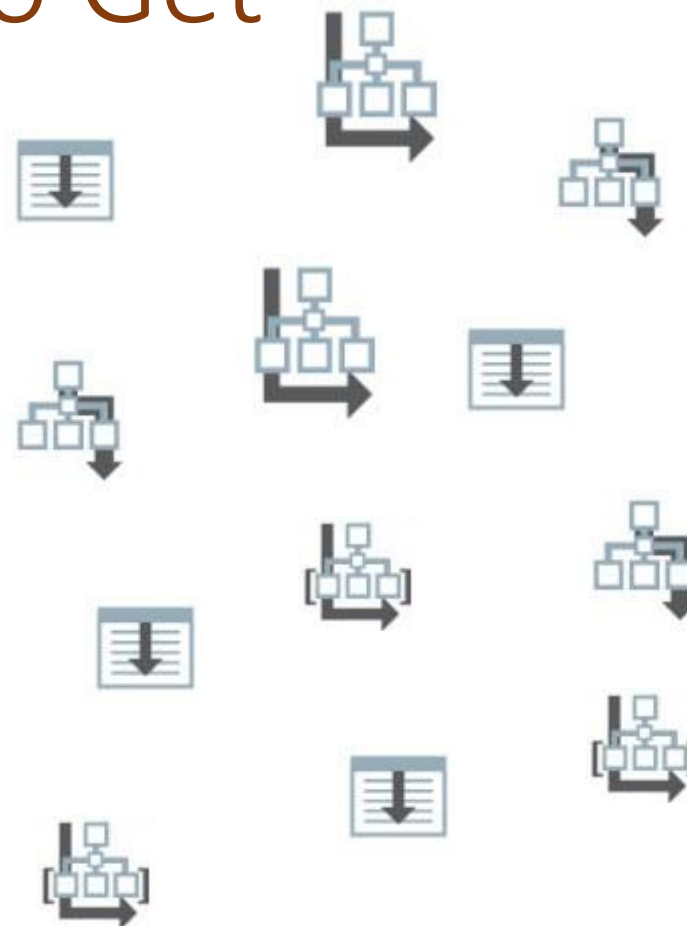
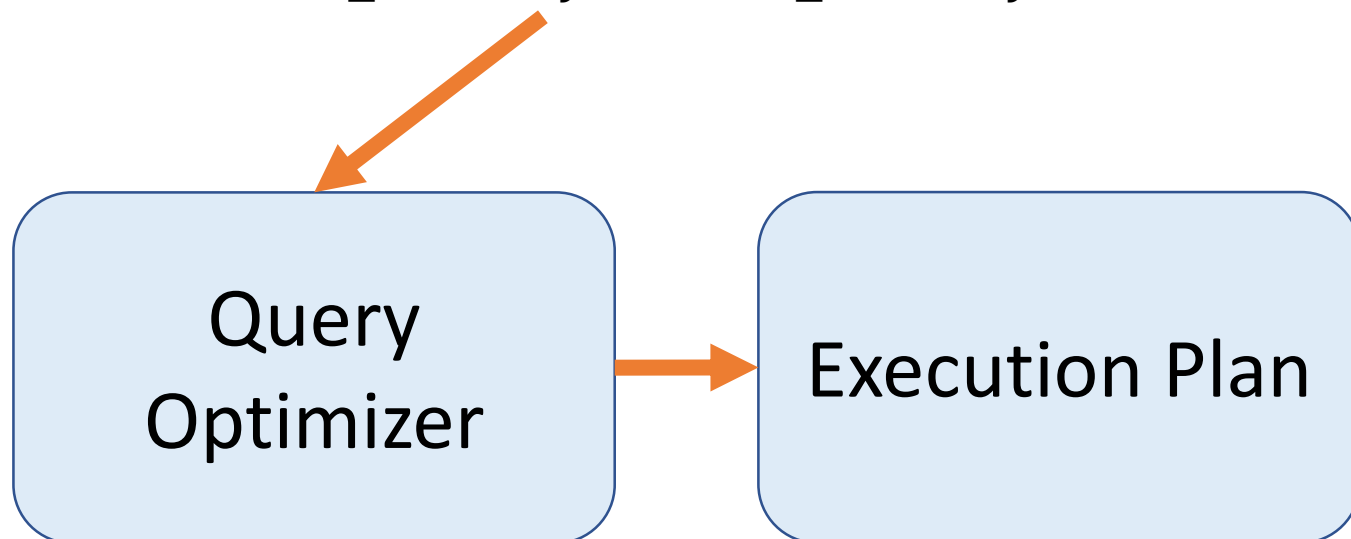
B-Tree – Clustered & Non-Clustered Idx



Internals: Navigating Heaps & Indexes

T-SQL: How To Get vs What To Get

```
SELECT  
    ColA, ColB, ...  
FROM Table_One  
INNER JOIN Table_Two  
    ON Table_One.Pkey = Table_Two.Fkey
```



Customer Table

```
CREATE TABLE dbo.Customer (  
    FirstName          VARCHAR(50),  
    LastName           VARCHAR(50),  
    Address            VARCHAR(50),  
    City               VARCHAR(50),  
    State              CHAR(2),  
    ZipCode            CHAR(5),  
    Email              VARCHAR(50),  
    FirstVisit         DATE,  
    RepeatCustomer     BIT  
);
```

Heap

Simpson, Mary,..
..,2003-01-08,0
Chavez, Esme,...,
2003-09-26,0
Ramirez, Lori,...,
2002-01-17,0

Martinez, Luis,...
,2003-08-19,0
Simon, Paul,...,2
002-06-28,1
Hu, Li,...,2002-
01-28,0

Raji, Bo,...,2004-
04-20,1
Agbonile, Lisa,...,
2004-01-01,0
Sandberg, Ryne,.
..,2003-11-06,1

Chow, Matt,...,20
01-11-12,0
Umeda, Umesh,.
..,2003-10-13,1
Howard, Kate,...,
2002-02-14,1

McDon, Jynell,...,
2004-03-09,0
Sanchez, Ray,...,2
002-01-17,0
Adams, James,...
,2002-02-10,1

Truempy, Nick,...
,2001-07-28,0
Mehta, Rit,...,20
04-05-19,1
Raman, Arthur,...
,2001-12-20,1

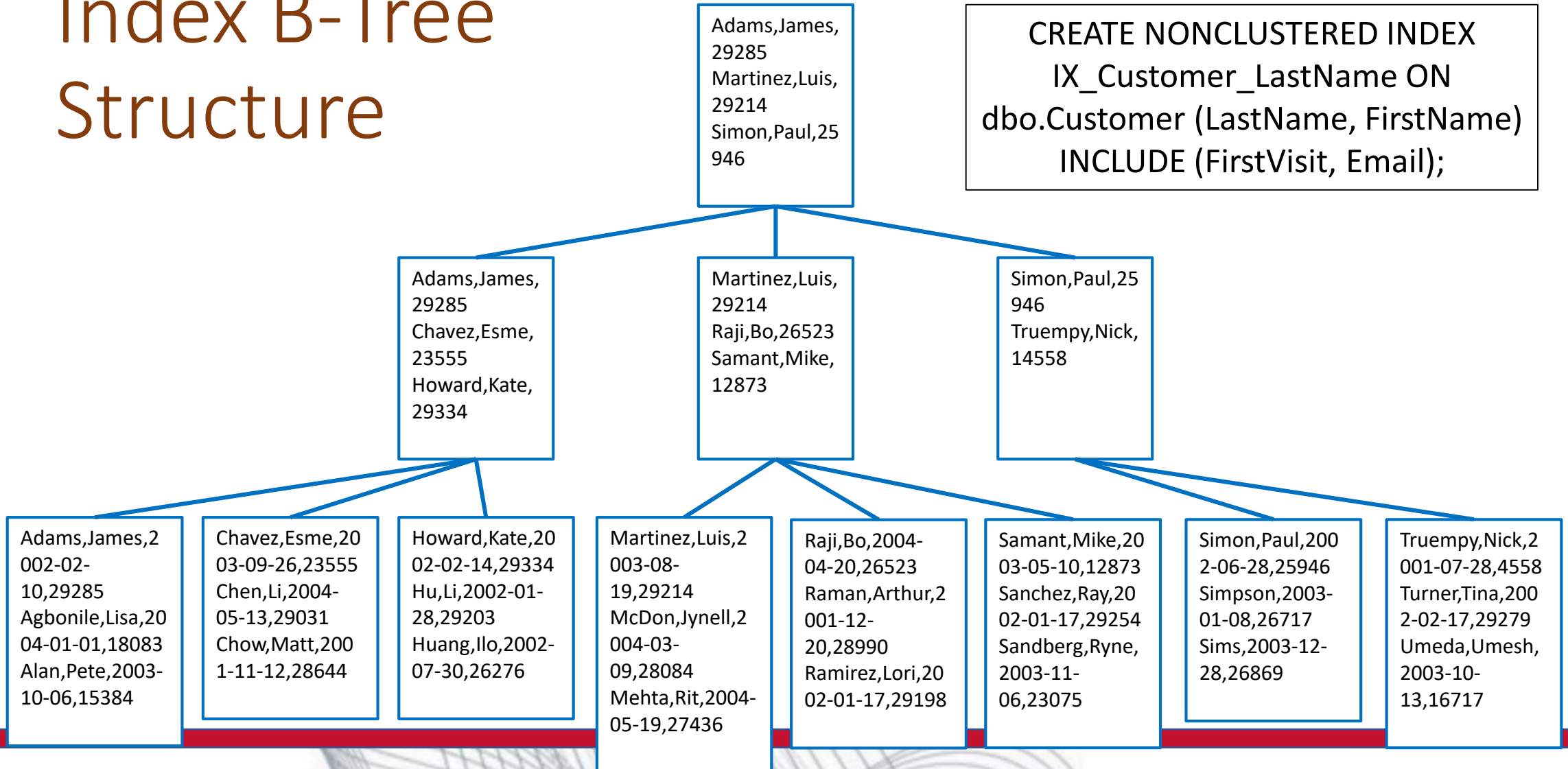
Huang, Ilo,...,200
2-07-30,1
Samant, Mike,...,
2003-05-10,1
Alan, Pete,...,200
3-10-06,1

Sims, Beth,...,20
03-12-28,0
Chen, Li,...,2004-
05-13,1
Turner, Tina,...,2
002-02-17,1

```
CREATE TABLE dbo.Customer (  
    CustomerID          INT IDENTITY(1, 1) PRIMARY KEY CLUSTERED,  
    FirstName           VARCHAR(50),  
    LastName            VARCHAR(50),  
    Address              VARCHAR(50),  
    City                 VARCHAR(50),  
    State                CHAR(2),  
    ZipCode              CHAR(5),  
    Email                VARCHAR(50),  
    FirstVisit           DATE,  
    RepeatCustomer       BIT  
);  
  
CREATE NONCLUSTERED INDEX IX_Customer_LastName  
    ON dbo.Customer (LastName, FirstName)  
    INCLUDE (FirstVisit, Email);
```

Index B-Tree Structure

```
CREATE NONCLUSTERED INDEX  
IX_Customer_LastName ON  
dbo.Customer (LastName, FirstName)  
INCLUDE (FirstVisit, Email);
```



Root Level

```
CREATE NONCLUSTERED INDEX  
    IX_Customer_LastName  
    ON dbo.Customer  
    (LastName, FirstName)  
    INCLUDE (FirstVisit, Email);
```

- Adams,James,29285
- Martinez,Luis,29214
- Simon,Paul,25946

Intermediate Level

```
CREATE NONCLUSTERED INDEX  
IX_Customer_LastName  
ON dbo.Customer  
(LastName, FirstName)  
INCLUDE (FirstVisit, Email);
```

- Adams,James,29285
- Chavez,Esme,23555
- Howard,Kate,29334

- Adams,James,29285
- Martinez,Luis,29214
- Simon,Paul,25946

- Martinez,Luis,29214
- Raji,Bo,26523
- Samant,Mike,12873

Leaf Level

```
CREATE NONCLUSTERED INDEX  
IX_Customer_LastName  
ON dbo.Customer  
(LastName, FirstName)  
INCLUDE (FirstVisit, Email);
```

- Adams,James,2002-02-10,jada@x.com,29285
- Agbonile,Lisa,2004-01-01,lagb@x.com,18083
- Alan,Pete,2003-10-06,pala@x.com15384

- Adams,James,29285
- Chavez,Esme,23555
- Howard,Kate,29334

- Chavez,Esme,2003-09-26,echa@x.com,23555
- Chen,Li,2004-05-13,lche@x.com29031
- Chow,Matt,2001-11-12,mcho@x.com28644

Querying a Heap

```
SELECT
  FirstName, LastName, FirstVisit
FROM Customer
WHERE LastName = 'Dean'
```

Simpson, Mary, .., 2003-01-08, 0
Chavez, Esme, ..., 2003-09-26, 0
Ramirez, Lori, ..., 2002-01-17, 0

Martinez, Luis, ..., 2003-08-19, 0
Simon, Paul, ..., 2002-06-28, 1
Hu, Li, ..., 2002-01-28, 0

Raji, Bo, ..., 2004-04-20, 1
Agbonile, Lisa, ..., 2004-01-01, 0
Sandberg, Ryne, .., 2003-11-06, 1

Chow, Matt, ..., 2001-11-12, 0
Umeda, Umesh, .., 2003-10-13, 1
Howard, Kate, ..., 2002-02-14, 1

McDon, Jynell, ..., 2004-03-09, 0
Sanchez, Ray, ..., 2002-01-17, 0
Adams, James, ..., 2002-02-10, 1

Truempy, Nick, ..., 2001-07-28, 0
Mehta, Rit, ..., 2004-05-19, 1
Raman, Arthur, ..., 2001-12-20, 1

Huang, Ilo, ..., 2002-07-30, 1
Samant, Mike, ..., 2003-05-10, 1
Alan, Pete, ..., 2003-10-06, 1

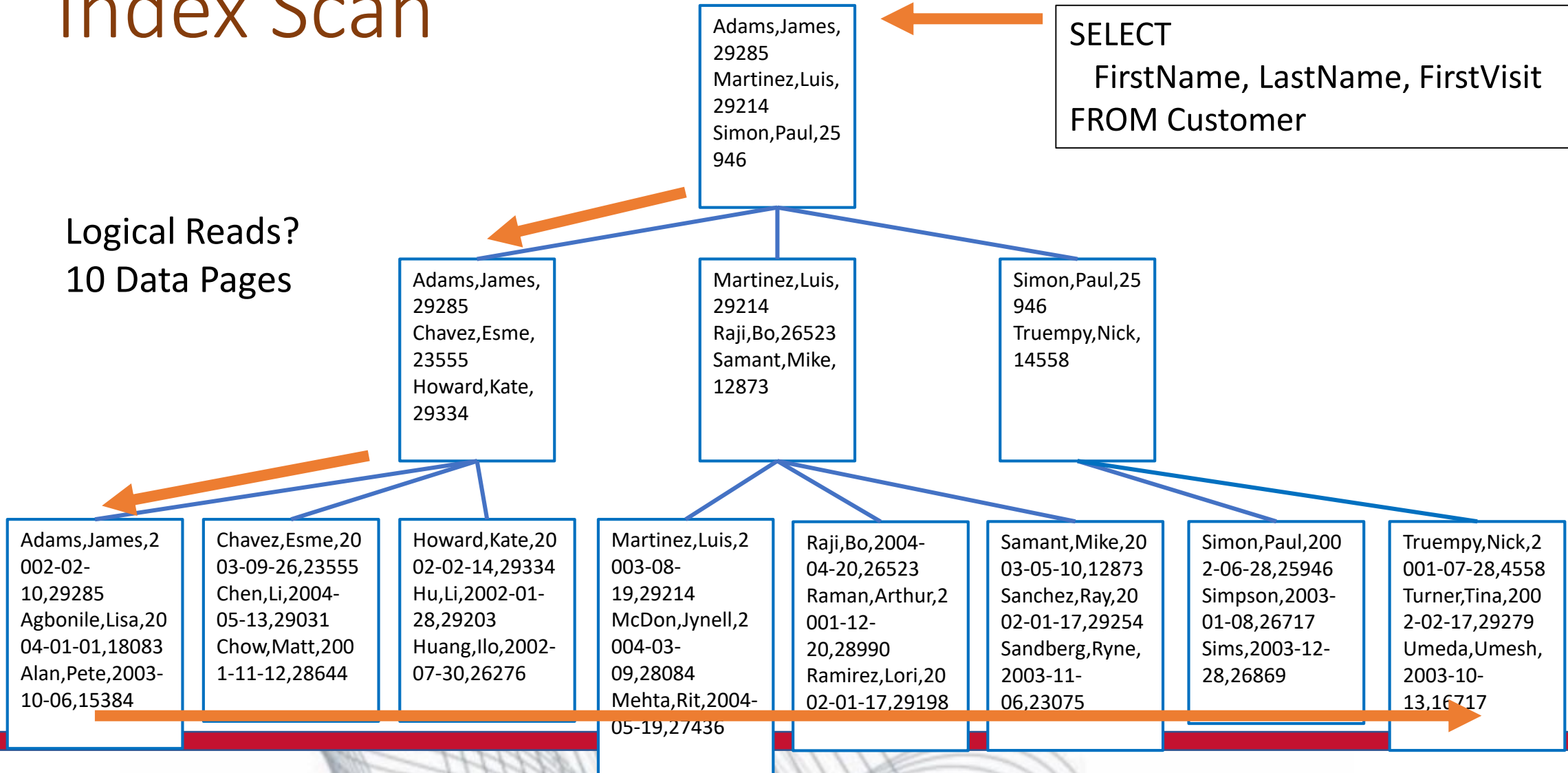
Sims, Beth, ..., 2003-12-28, 0
Chen, Li, ..., 2004-05-13, 1
Turner, Tina, ..., 2002-02-17, 1

Logical Reads?
8 Data Pages

Index Scan

```
SELECT  
  FirstName, LastName, FirstVisit  
FROM Customer
```

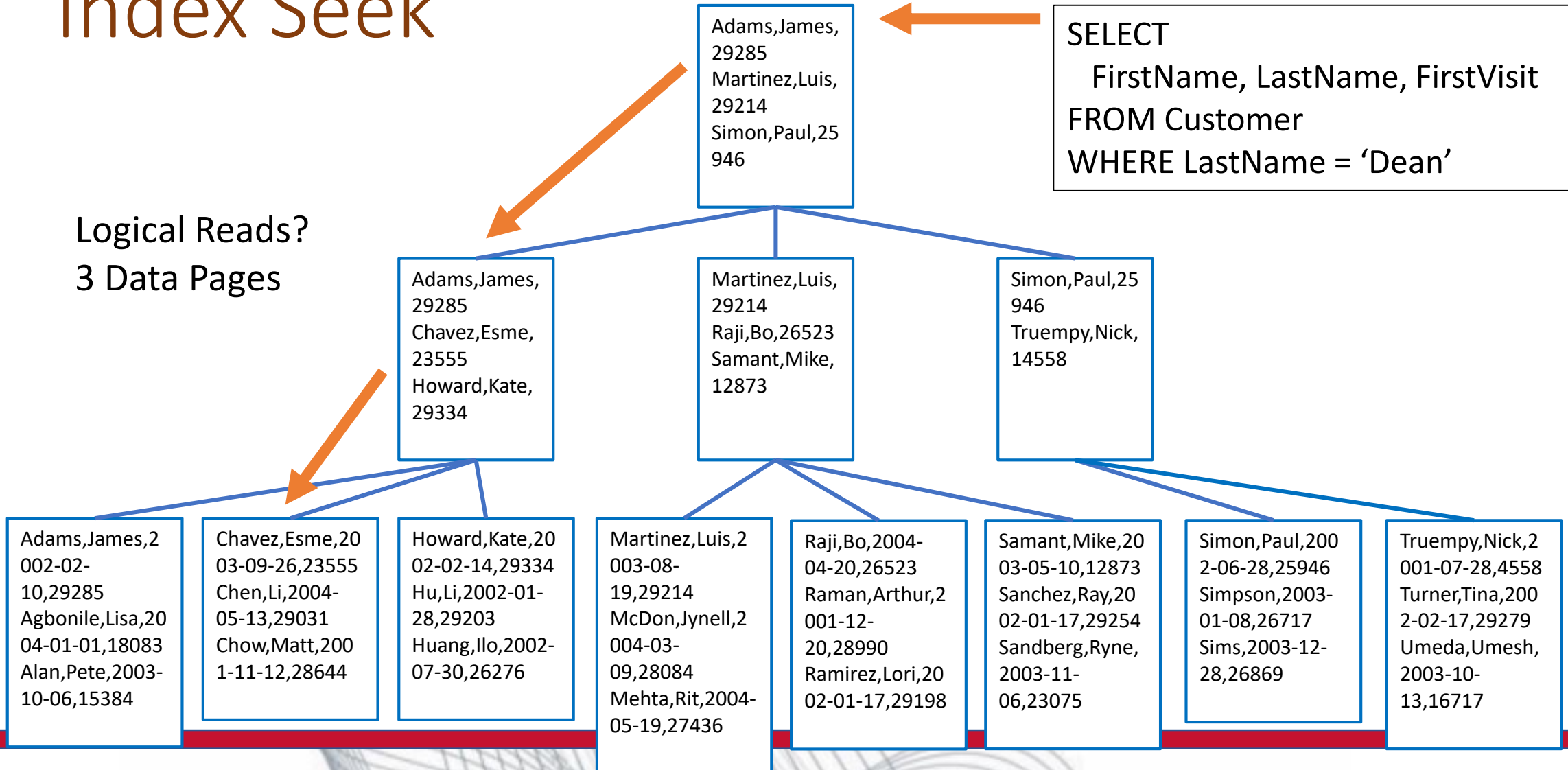
Logical Reads?
10 Data Pages



Index Seek

```
SELECT  
  FirstName, LastName, FirstVisit  
FROM Customer  
WHERE LastName = 'Dean'
```

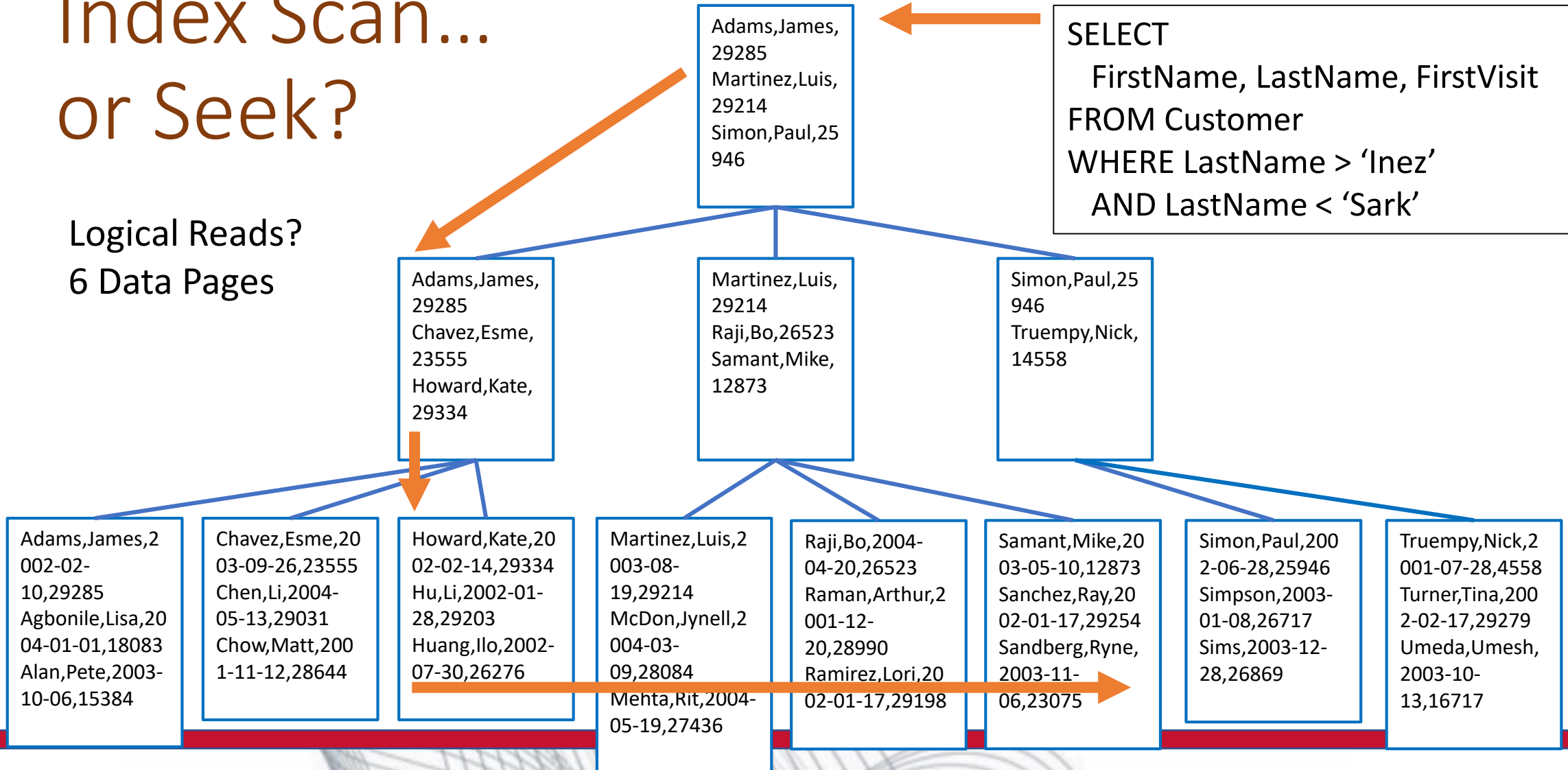
Logical Reads?
3 Data Pages



Index Scan... or Seek?

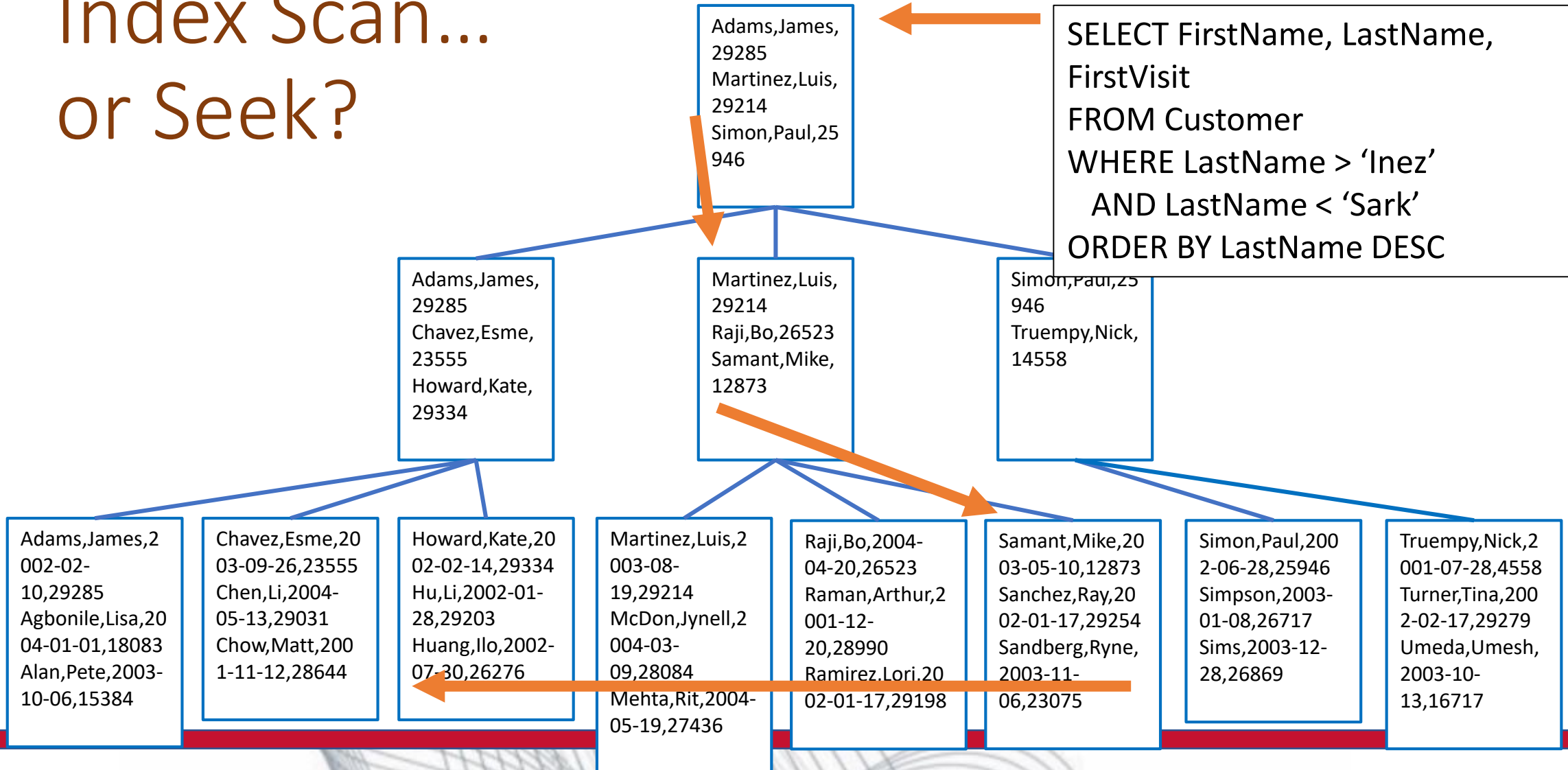
Logical Reads?
6 Data Pages

```
SELECT
  FirstName, LastName, FirstVisit
FROM Customer
WHERE LastName > 'Inez'
  AND LastName < 'Sark'
```



Index Scan... or Seek?

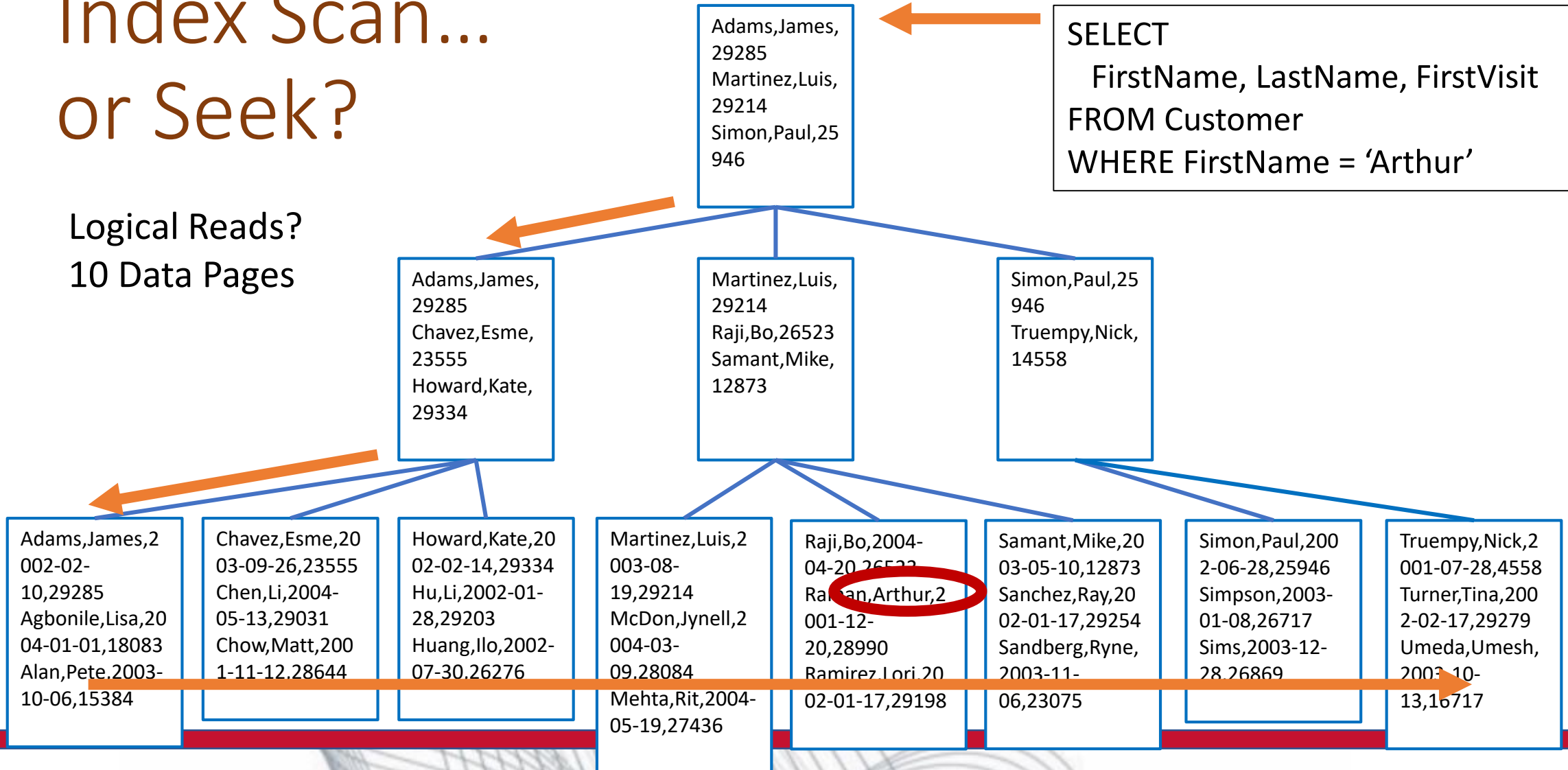
```
SELECT FirstName, LastName,  
FirstVisit  
FROM Customer  
WHERE LastName > 'Inez'  
AND LastName < 'Sark'  
ORDER BY LastName DESC
```



Index Scan... or Seek?

Logical Reads?
10 Data Pages

```
SELECT  
  FirstName, LastName, FirstVisit  
FROM Customer  
WHERE FirstName = 'Arthur'
```

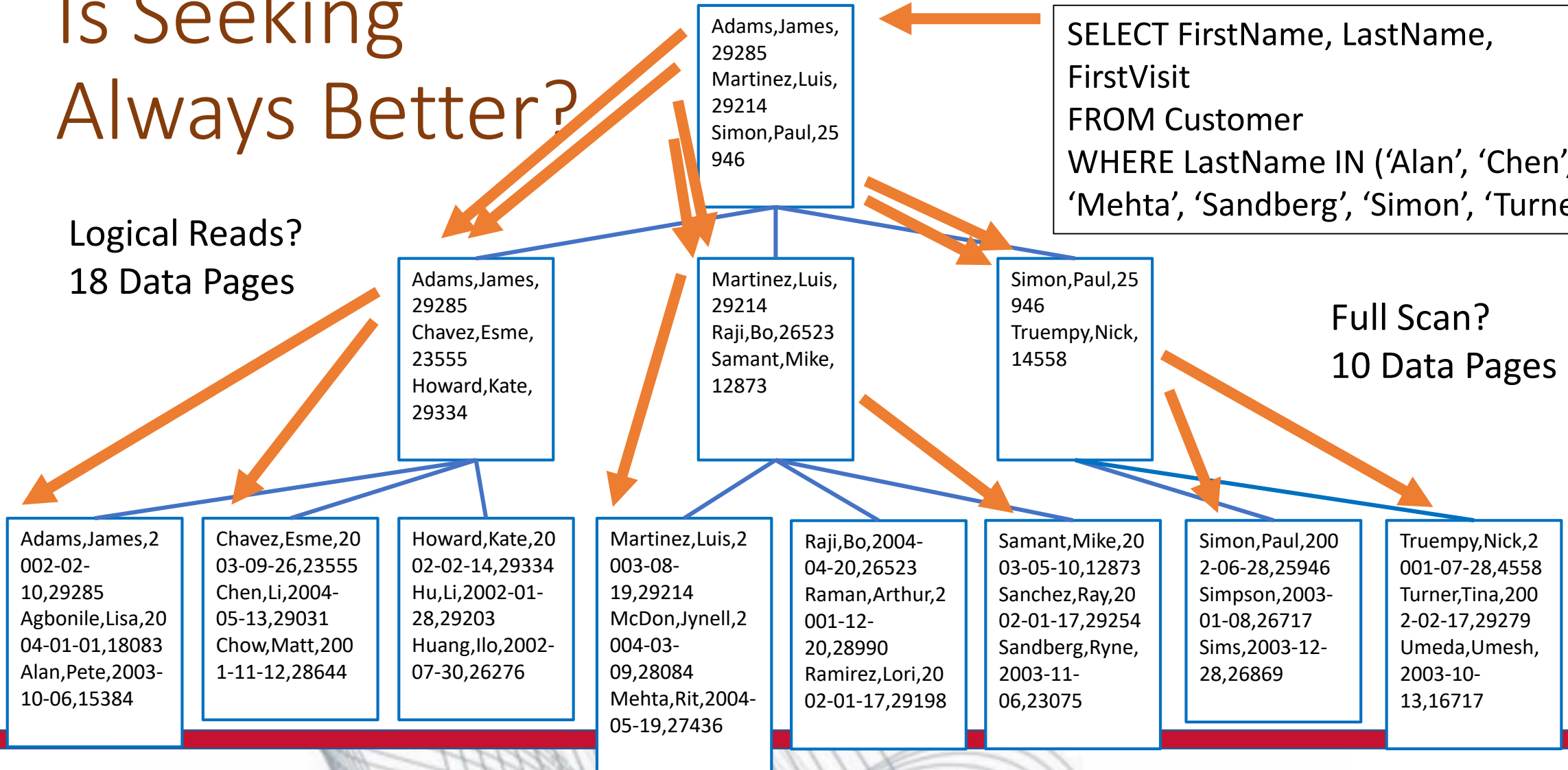


Is Seeking Always Better?

Logical Reads?
18 Data Pages

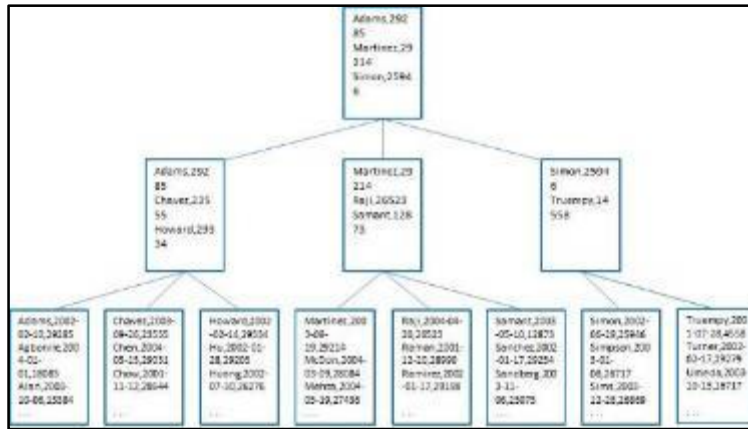
```
SELECT FirstName, LastName,  
FirstVisit  
FROM Customer  
WHERE LastName IN ('Alan', 'Chen',  
'Mehta', 'Sandberg', 'Simon', 'Turner')
```

Full Scan?
10 Data Pages



Key Lookup

```
SELECT  
  FirstName, LastName,  
  FirstVisit, City, State  
FROM Customer  
WHERE LastName = 'Huang'
```



Adams, James,
29285
Martinez, Luis,
29214
Simon, Paul, 25
946

Martinez, Luis,
29214
Raji, Bo, 26523
Samant, Mike,
12873

Simon, Paul, 25
946
Truempy, Nick,
14558

Adams, James, 2
002-02-
10, 29285
Agbonile, Lisa, 20
04-01-01, 18083
Alan, Pete, 2003-
10-06, 15384

Chavez, Esme, 20
03-09-26, 25555
Chen, Li, 2004-
05-13, 29031
Chow, Matt, 200
1-11-12, 28644

Howard, Kate, 20
02-02-14, 29334
Hu, Li, 2002-01-
28, 29203
Huang, Ilo, 2002-
07-30, 26276

Martinez, Luis, 2
003-08-
19, 29214
McDon, Jynell, 2
004-03-
09, 28084
Mehta, Rit, 2004-
05-19, 27436

Raji, Bo, 2004-
04-20, 26523
Raman, Arthur, 2
001-12-
20, 28990
Ramirez, Lori, 20
02-01-17, 29198

Samant, Mike, 20
03-05-10, 12873
Sanchez, Ray, 20
02-01-17, 29254
Sandberg, Ryne,
2003-11-
06, 23075

Simon, Paul, 200
2-06-28, 25946
Simpson, 2003-
01-08, 26717
Sims, 2003-12-
28, 26869

Truempy, Nick, 2
001-07-28, 4558
Turner, Tina, 200
2-02-17, 29279
Umeda, Umesh,
2003-10-
13, 16717

Index Operation Recap

- Index Key Order Matters. Can only seek on leading key column
- Add Appropriate Columns as Included Columns to “Cover a Query”
- Seeks are not necessarily better than Scans – Check Properties in Execution Plan

DEMO: T-SQL & I/O Scenarios

Parting Thoughts

Widen Your Perspective

Server Resources Are A Shared Pool

Thank you!

<https://github.com/SQLBek>

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<http://sqlbek.wordpress.com>

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