Progress OpenEdge Multi-tenant Database

Workshop

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PROGRESS EXCHANGE 2013

DISCOVER. DEVELOP. DELIVER.

Introduction

This workshop is intended to introduce you to the inbuilt multi-tenant capabilities of the OpenEdge 11 RDBMS and show you how to make use of them in 4GL applications.

We have alternated between lecture and hands-on segments so you will have a chance to try for yourself the things that we will talk about.

Preliminaries

- Ask questions when you wish
- Focus of labs is on basic 4GL ***programming*** for data access. So sorry, no GUI stuff.
- Labs are not too long, except for the ones that are
- Take bio breaks as needed when you finish a lab

LAB Machines

- You each get your own virtual lab machine
- Hosted on Amazon EC2 and accessible via Windows Remote Desktop
- The OpenEdge 11.3.1 release
- The directory C:\mt has some files you will need for the lab portions

LABs

- Handouts have detailed instructions for each lab
- We have helpers who will assist you if you need help with something or you get stuck
- If you finish a lab section early, you can explore or try some other things while you wait for everyone else to finish.

Lab 0

Get connected to your Amazon EC2 AMI

Multi-tenant concepts

Who Cares about Multi-tenancy?

SaaS vendors do.

- Lower costs and operational excellence
  - Reduce machine resource requirements (cpu, memory, and disk)
  - Reduce operational costs
  - Reduce the number of instances
  - Cheaper and easier to manage
  - Requires fewer administration staff
  - Gain economies of scale
- Service efficiency is accomplished best by automation, which requires consistency
  - One good way to make that happen for application delivery is with multi-tenancy ...

Who Cares about Multi-tenancy?

SaaS vendors do.

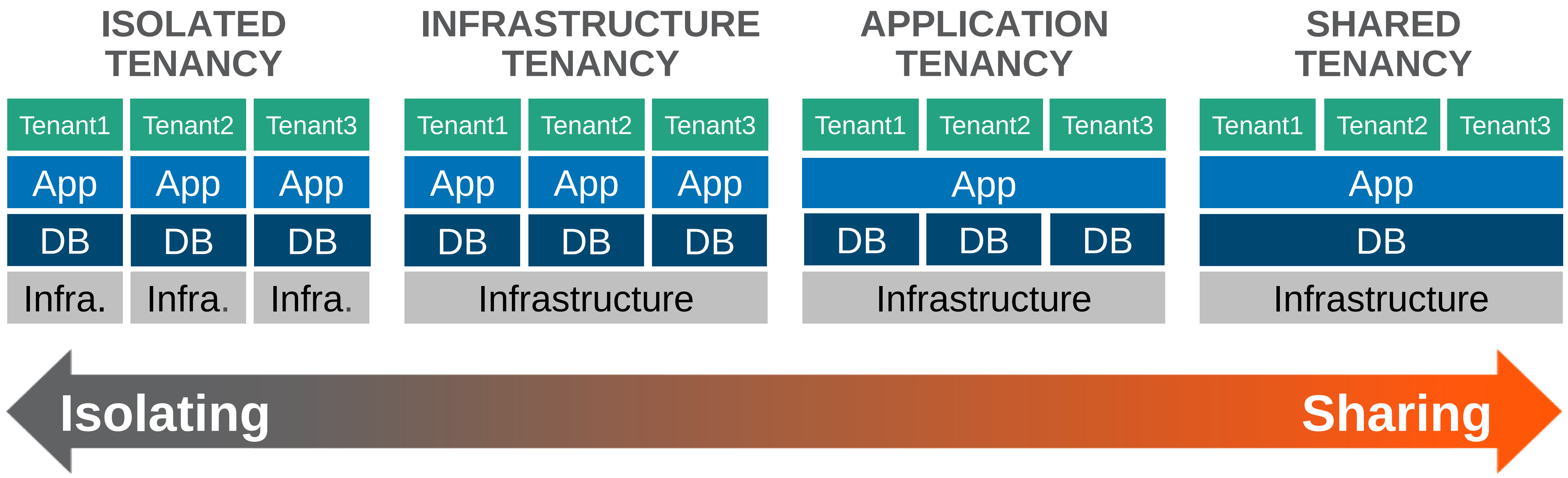
Much to our surprise, we found that people who do not do SaaS are interested too.

What is a Tenant Anyway?

Tenants are:

- Named groups of people (users) that are related in some (organizational) way, share data, and use the same application(s)
- They might work in the same company, work in same division or dept. of a larger company, or belong to the same club
- Tenants don't know others may be using the same system
- For example, tenants could be the makers of these fine refreshing beverages:

Multi-tenancy Options Continuum



- Easier customization, security
- Simpler throttling control
- Target dissimilar customers
- No transformation

- Better economy of scale
- Simpler management
- Target like-customers
- Least cost to serve

Why Multi-tenancy? Vendors Want to...

- Increase infrastructure efficiency
  - Do the job will less hardware or more with same
- Reduce operational and administrative labor
  - Do the job with less work
- Decrease operating costs
  - Allow higher profits to provider
  - Allow lower prices to customers

SaaS Application Customers Want

- Low startup cost
- Fast deployment
- 100% uptime
- Responsive applications
- Data security (well, they *should* anyway)
- Low prices

Why *Database* Multi-tenancy?

- Lower SaaS application development cost and time
- Lower SaaS application deployment cost and time
- Lower operational costs
- Lower administrative costs
- Provide more flexibility for OpenEdge ISV partners
- Provide more flexibility for OpenEdge customers

In 10.2B, you can do this:

Extra “Tenant ID” Column for Multi-tenancy

	Tenant ID	Cust ID	Name
	A	1	Lift Line Skiing
Tenant A Rows	A	2	Urban Frisbee
	A	3	Hoops Croquet
	B	1	Fanatical Athletes
Tenant B Rows	B	8	Game Set Match
	B	9	Lift Line Skiing
	C	2	High Tide Sailing
Tenant C Rows	C	7	Pedal Power
	C	9	Hoops Croquet

FOR EACH CUSTOMER WHERE (TenantID = A) and (regular stuff):

What's wrong with that?

Do we need more?

It Works, But There Are Just a Few Small Disadvantages

- Invasive: you have to change a lot of 4GL code
- Mistakes likely – then data given to wrong tenant
- Lock conflicts can occur among tenants
- Suboptimal performance
  - Low locality of reference
  - Low database buffer cache efficiency
  - Low I/O efficiency

And Still Other Disadvantages

- Per tenant bulk operations difficult
  - Backup, restore, reindex, delete, copy, move
- Tenant-level performance analysis difficult
- Tenant resource consumption metrics difficult
- Tenant resource utilization controls difficult
- and a bunch of other things

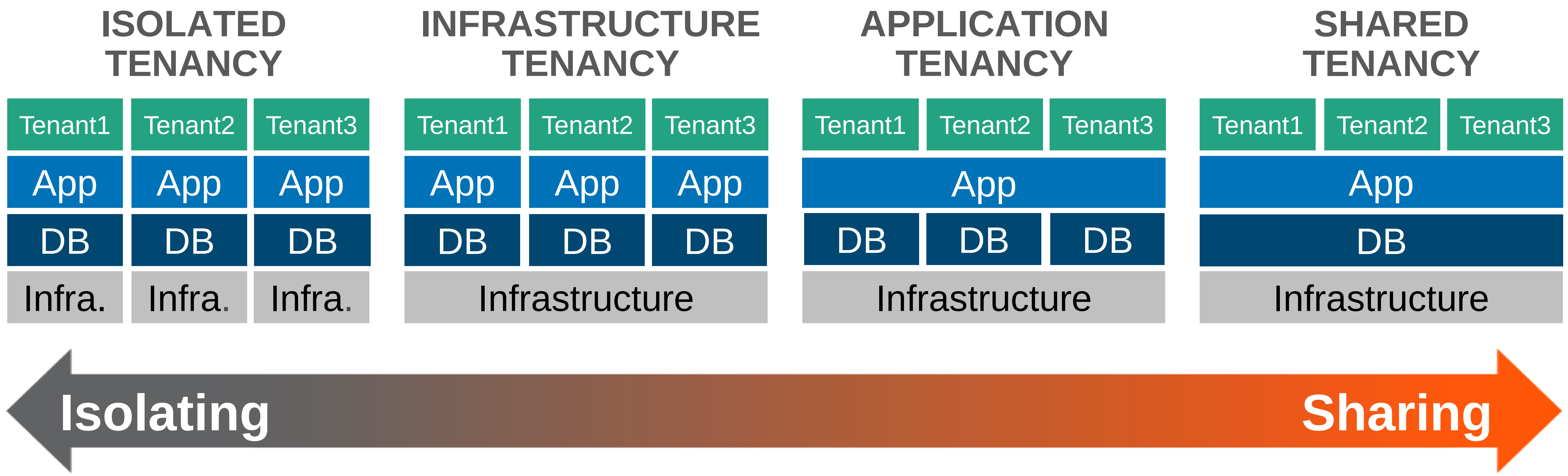
Yes! You do need more.
And with OpenEdge 11, you get more.

The RDBMS has inbuilt multi-tenancy for both 4GL and SQL applications

Main purpose of OpenEdge 11 inbuilt multi-tenancy is to: Reduce costs for SaaS vendors

How does it work?

Multi-tenancy Options Continuum



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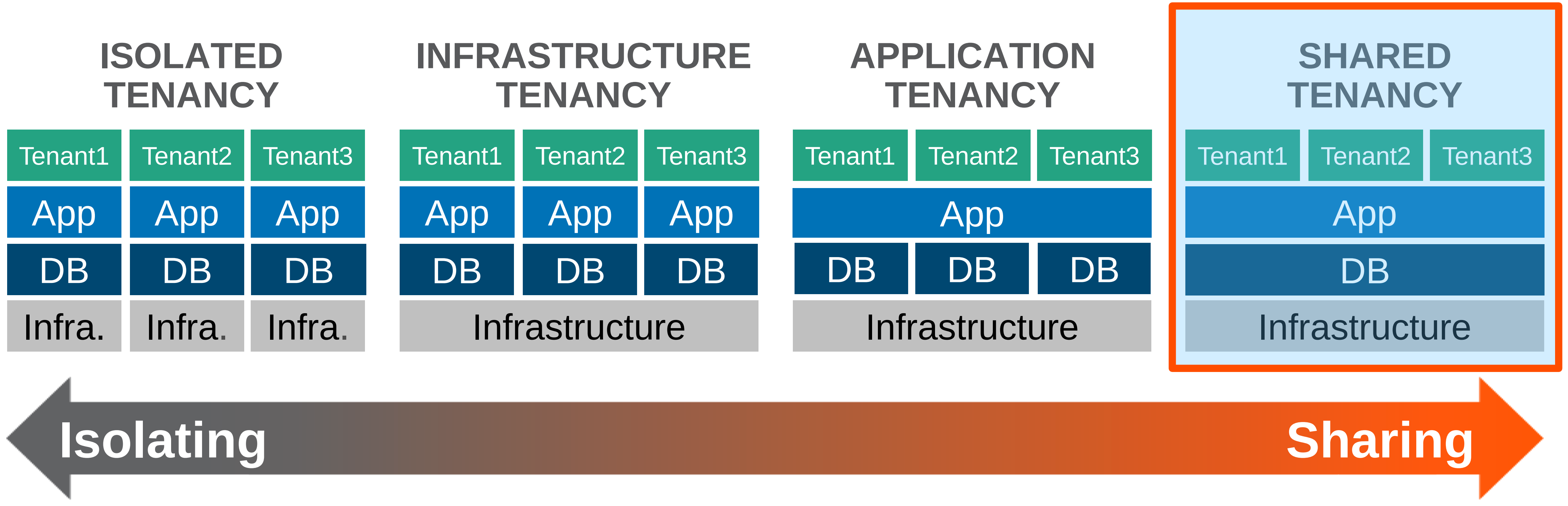
Multi-tenancy Options Continuum



- Easier customization, security
- Simpler throttling control
- Target dissimilar customers
- No transformation

- Better economy of scale
- Simpler management
- Target like-customers
- Least cost to serve

OpenEdge Multi-tentant Tables: NO Extra Column for Tenant ID

	~~Tenant ID~~	Cust ID	Name
	~~A~~	1	Lift Line Skiing
Tenant A Rows	~~A~~	2	Urban Frisbee
	~~A~~	3	Hoops Croquet
	~~B~~	1	Fanatical Athletes
Tenant B Rows	~~B~~	8	Game Set Match
	~~B~~	9	Lift Line Skiing
	~~C~~	2	High Tide Sailing
Tenant C Rows	~~C~~	7	Pedal Power
	~~C~~	9	Hoops Croquet

FOR EACH CUSTOMER WHERE ~~(TenantID = A)~~

OpenEdge Multi-tentant Tables: NO Extra Column for Tenant ID

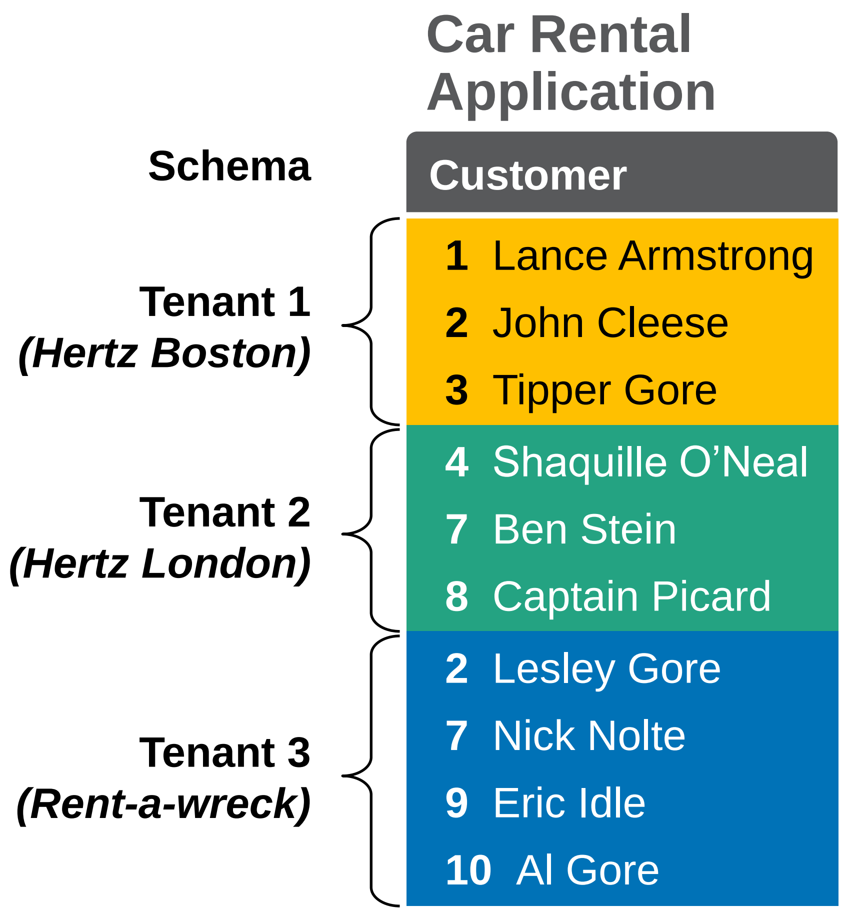
	Cust ID	Name
Tenant A Rows	1	Lift Line Skiing
	2	Urban Frisbee
	3	Hoops Croquet
Tenant B Rows	1	Fanatical Athletes
	8	Game Set Match
	9	Lift Line Skiing
Tenant C Rows	2	High Tide Sailing
	7	Pedal Power
	9	Hoops Croquet

FOR EACH CUSTOMER:

OE 11 Multi-tenant Tables

Multi-tenancy **Simplifies Development of Multi-tenant Applications**

- Multi-tenancy built into the database
- Data physically partitioned by tenant identity
- Tenants share same schema definition
- **Minimal** application changes
  - Just set a per-database tenant name

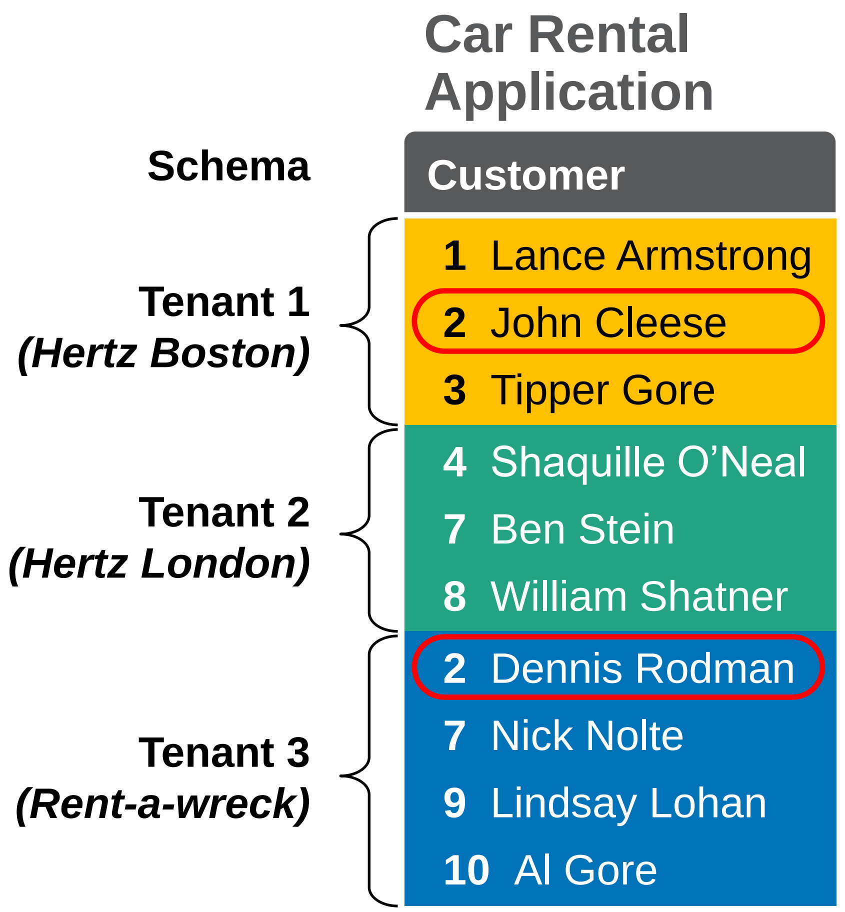


*Fictitious example

Multi-tenant Tables: Data Access

Multi-tenancy **Simplifies Development of Multi-tenant Applications**

- Keys unique per tenant partition



Car Rental Application

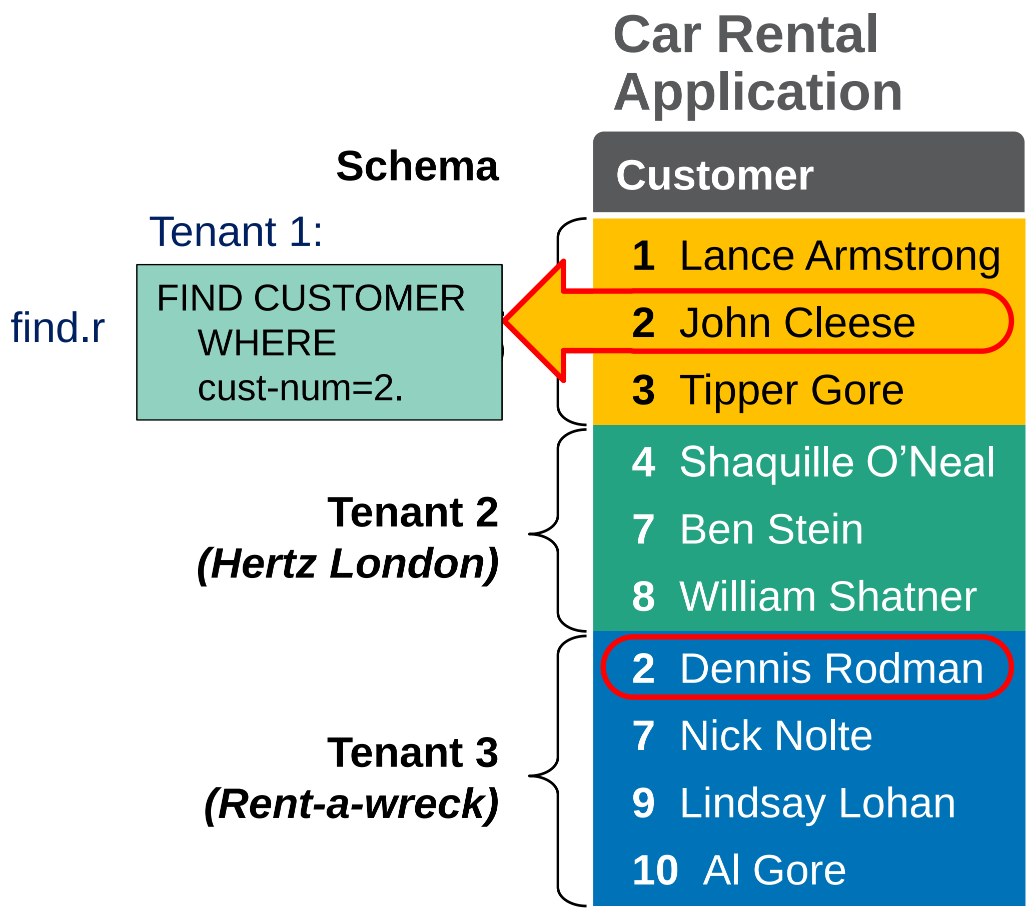
Schema	Customer
Tenant 1 ***(Hertz Boston)***	**1** Lance Armstrong
	2 John Cleese
	3 Tipper Gore
Tenant 2 ***(Hertz London)***	**4** Shaquille O'Neal
	7 Ben Stein
	8 William Shatner
Tenant 3 ***(Rent-a-wreck)***	**2** Dennis Rodman
	7 Nick Nolte
	9 Lindsay Lohan
	10 Al Gore

*Fictitious example

Multi-tenant Tables: Data Access

Multi-tenancy **Simplifies Development of Multi-tenant Applications**

- Keys unique per tenant partition
- Query is tenant-specific
  - Authenticate as tenant
    - _User
    - Client Principal
  - Assert tenant identity



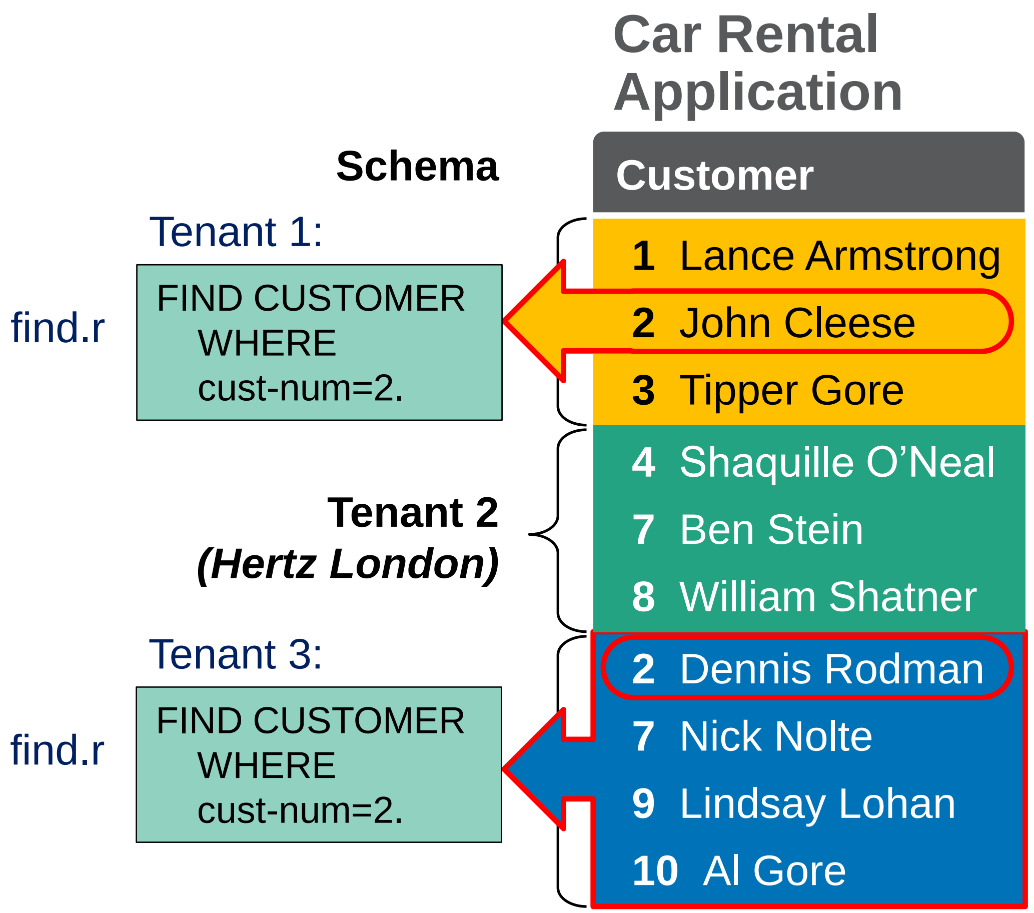
```
FIND CUSTOMER
   WHERE
   cust-num=2.
```

*Fictitious example

Multi-tenant Tables: Data Access

Multi-tenancy

- Keys unique per tenant partition
- Query is tenant-specific
  - Authenticate as tenant
    - _User
    - Client Principal
  - Assert tenant identity



*Fictitious example

Multi-tenant Tables: Data Access

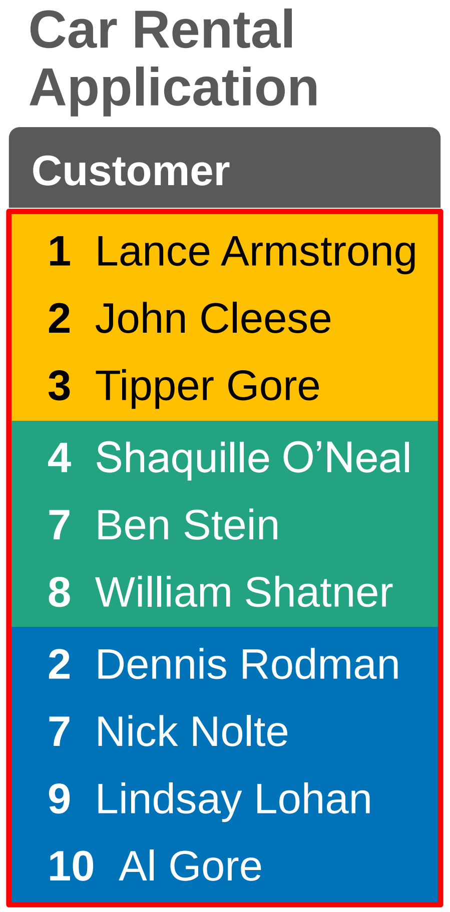
Multi-tenancy **Simplifies Development of Multi-tenant Applications**

- Keys unique per tenant partition
- Query is tenant-specific
- "Super-tenant" query
  - Authenticate & assert identity
  - No data of their "own"
  - Access to all tenant data by tenant ID or name

Schema

Super-tenant:

```
FOR EACH customer
 TENANT-WHERE
     Tenant-id > 0:
DISPLAY
    cust-num, name.
```



Car Rental Application

Customer	
1	Lance Armstrong
2	John Cleese
3	Tipper Gore
4	Shaquille O'Neal
7	Ben Stein
8	William Shatner
2	Dennis Rodman
7	Nick Nolte
9	Lindsay Lohan
10	Al Gore

*Fictitious example

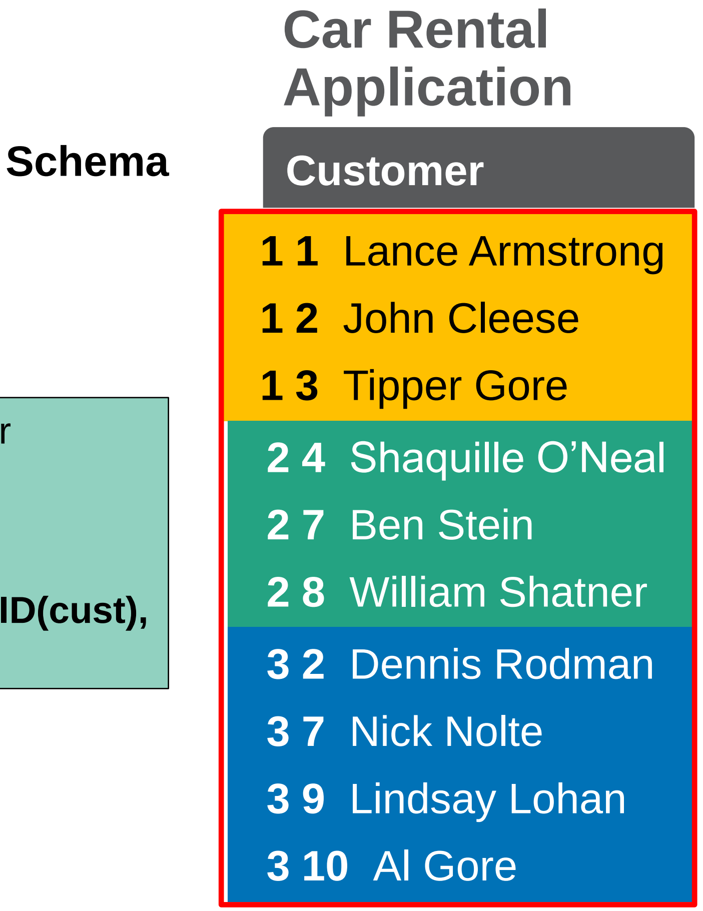
Multi-tenant Tables: Data Access

Multi-tenancy **Simplifies Development of Multi-tenant Applications**

- Keys unique per tenant partition
- Query is tenant specific
- “Super-tenant" query
- Row-level tenant identification
- Virtual column available for display or selection (not in table definition)

Super-tenant:

```
FOR EACH customer
  TENANT-WHERE
     Tenant-id > 0:
DISPLAY
  BUFFER-TENANT-ID(cust),
  cust-num, name.
```



1	1	Lance Armstrong
1	2	John Cleese
1	3	Tipper Gore
2	4	Shaquille O’Neal
2	7	Ben Stein
2	8	William Shatner
3	2	Dennis Rodman
3	7	Nick Nolte
3	9	Lindsay Lohan
3	10	Al Gore

*Fictitious example

3 Types of Tenants

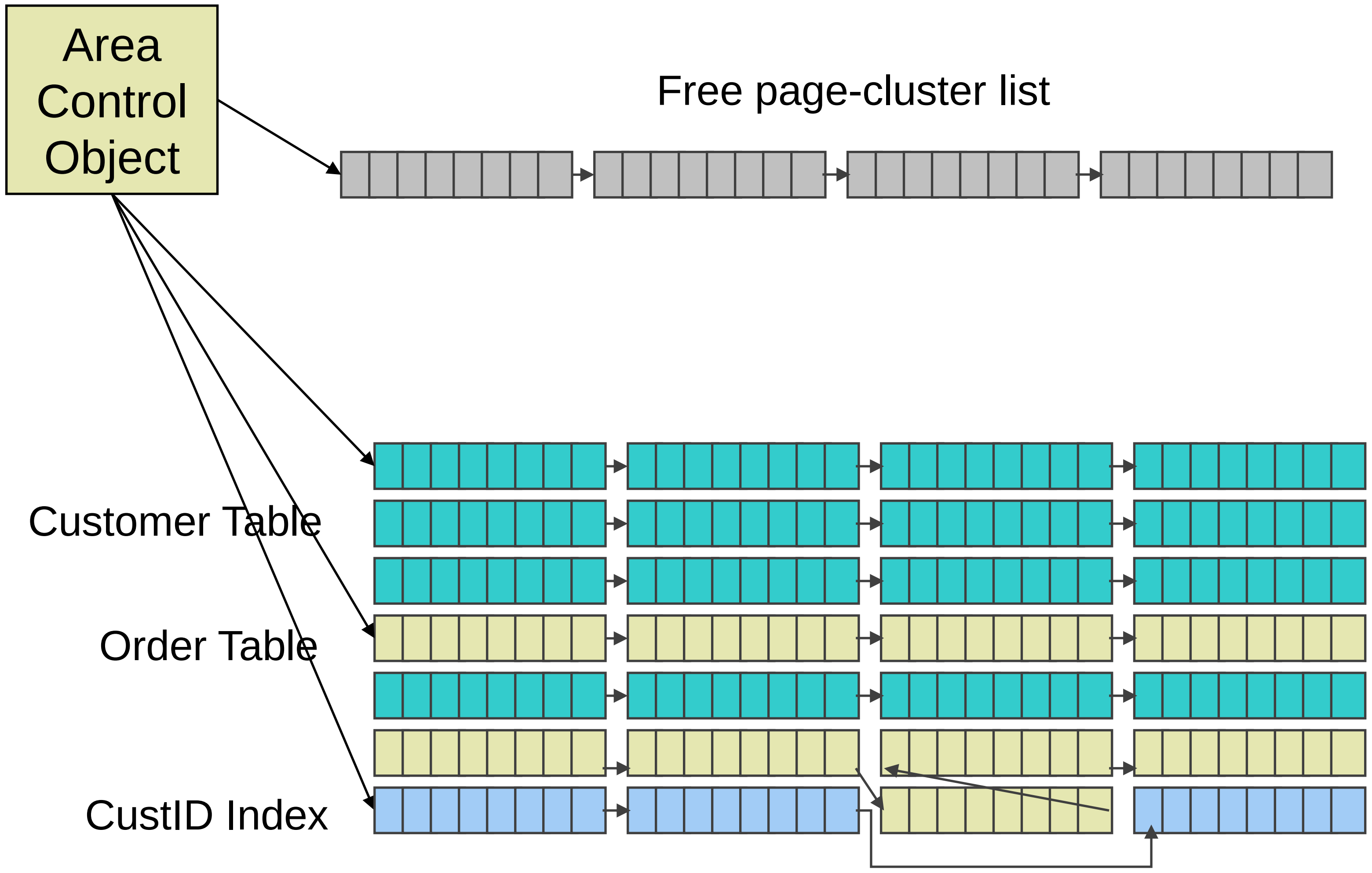
- Default
- Regular
- Super

Lab 1

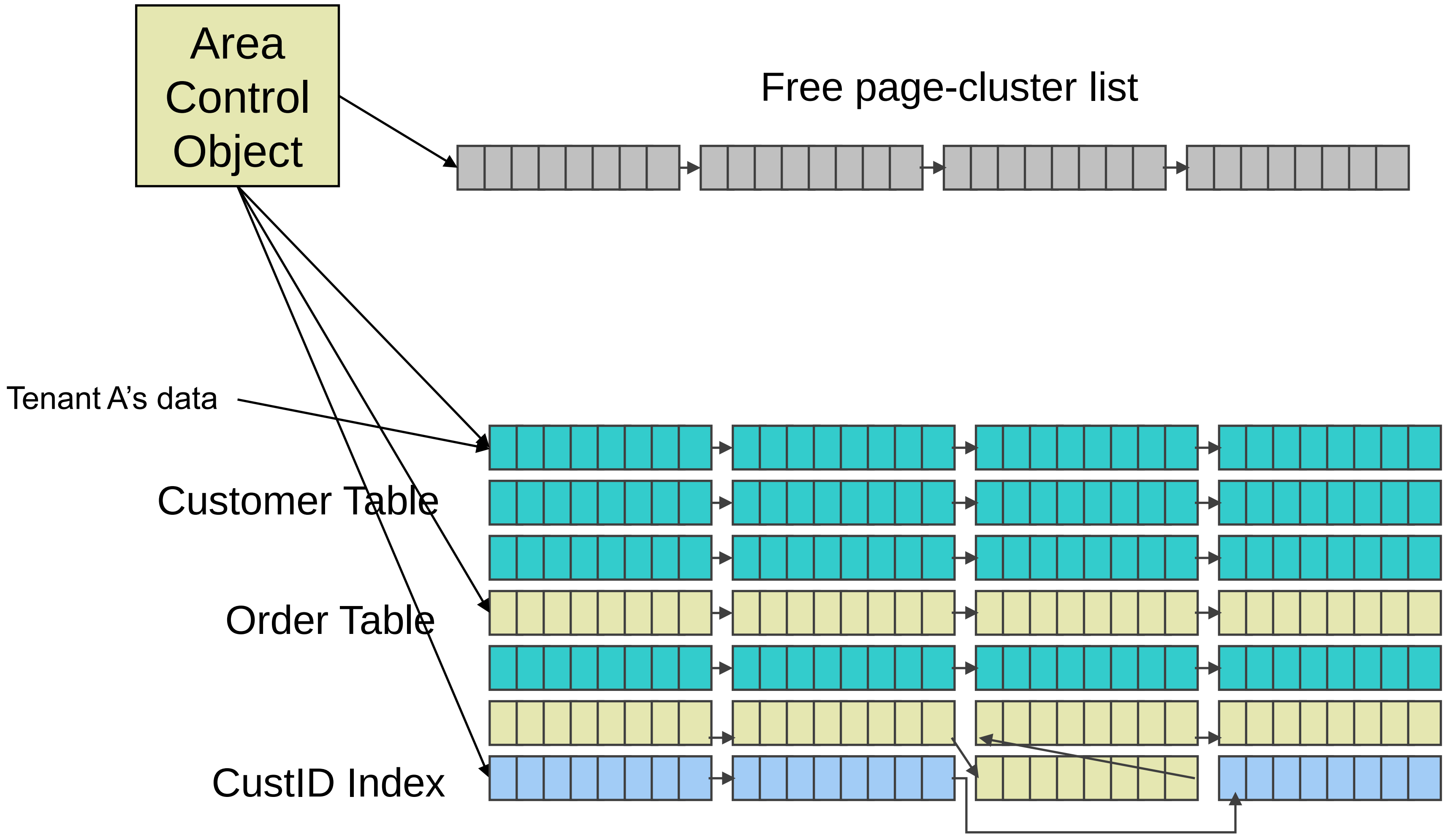
Creating a
multi-tenant database

Tenant data storage

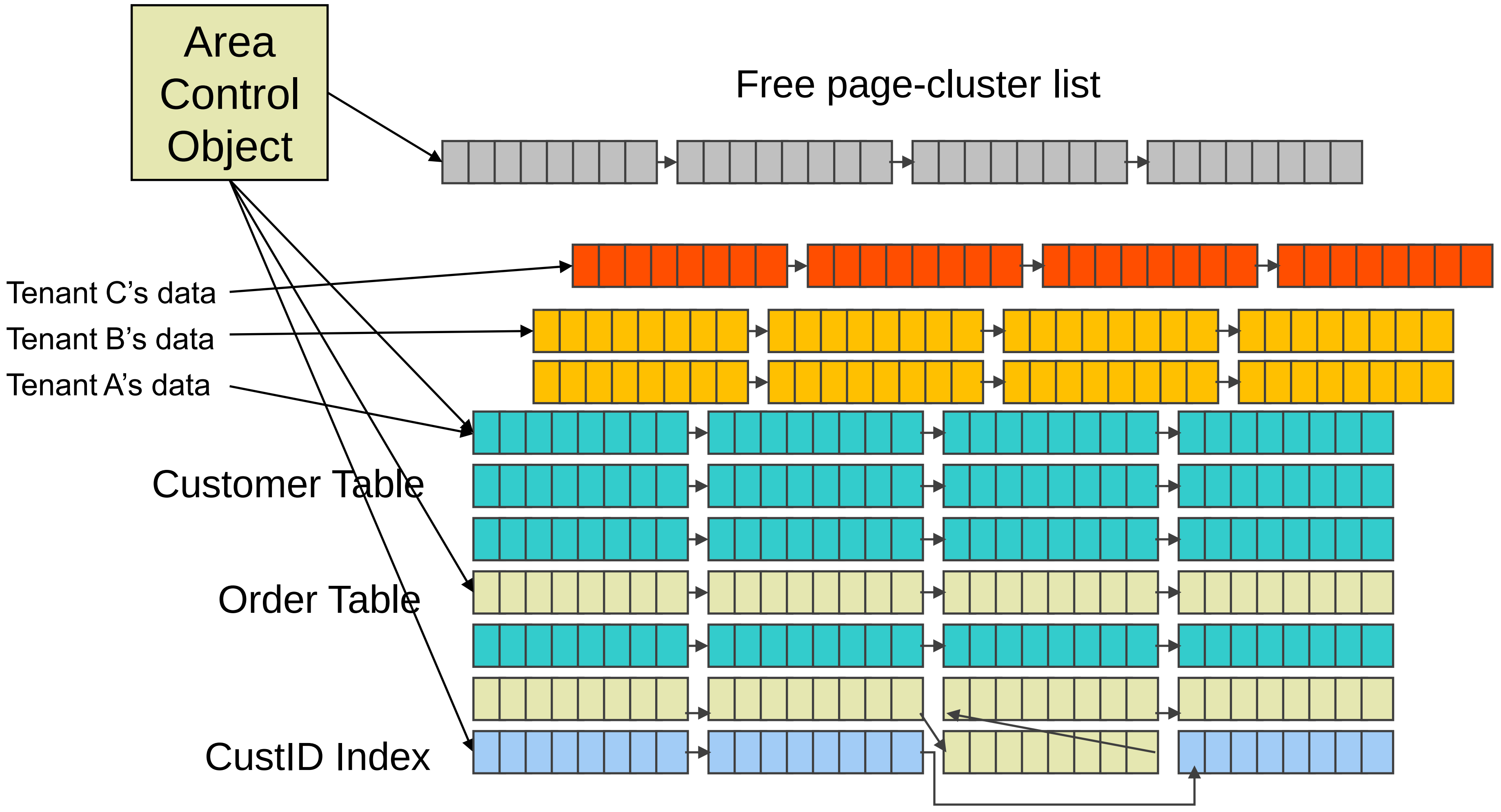
Multitenant Storage Area Structure: Tenant Data Partitions



Multitenant Storage Area Structure: Tenant Data Partitions

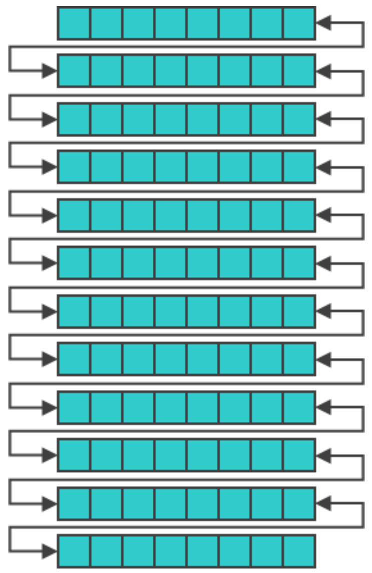


Multitenant Storage Area Structure: Tenant Data Partitions



Tables: Physical Storage View (Type ii Data Areas)

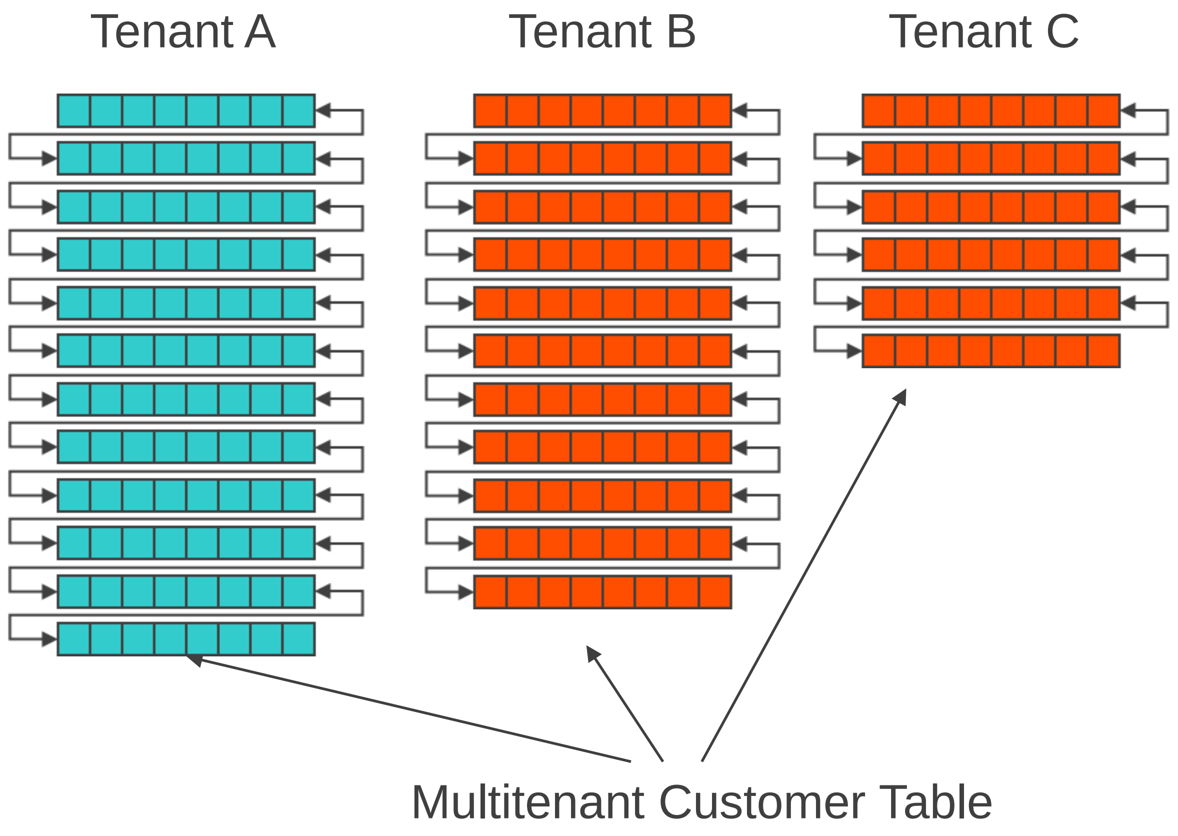
Linked list of page-clusters



Shared Customer Table

OpenEdge Multi-tenant Tables: Automatic Table Partition for Each Tenant

Linked list of page-clusters for each tenant's data



Numbers

500 tables

10 indexes per table (maybe a bit high)

100 tenants

= (500 * 100) + (500 * 10 * 100)

= 505,000 partitions !!!

Strategies for Storage Layout

With very many partitions, you have to keep it simple.

Strategies for Storage Layout

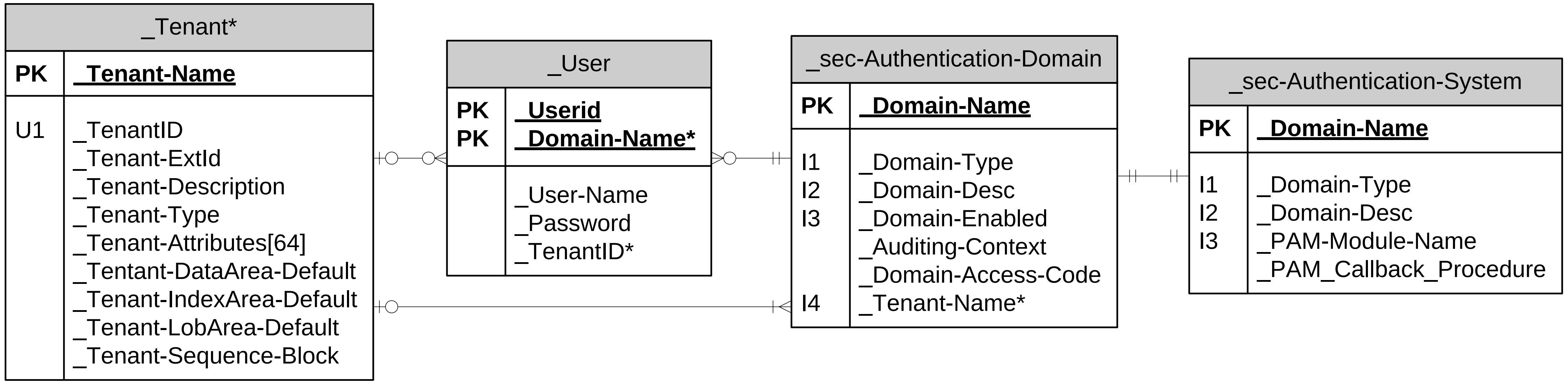
- Shared tables all in one area
- All tenants in one area
- 5 tenants per area
- "stripe" p partitions over n areas (p >> n)
- One storage area per tenant
- 3 areas per tenant (data, index, lob)

Tenants have their own data partitions

How does database know to which tenant a user belongs?

DOMAINS

- A tenant is a collection of users
- A user is a "person"
- A *security domain* is named set of rules ("policies") for how a group of users identity and tenant association is verified
- Every tenant must have *at least one* domain



DOMAINS

- When you create a tenant, you must also create a domain.
- The domain specifies how user identity is validated
- Possibilities include:
  - _user table has user name and password
  - operating system identity
  - external system like LDAP, Active Directory, etc.
  - Your 4GL code

How Users and Tenants Are Identified

- Users have names
- Tenants have domains
- Domains have names
- Together the two names are unique

user-name@domain-name

DOMAINS

When you log in
you must specify user id and
you must also specify a domain.

for example:
mpro –db foo –U user@domain –P password

we will see some other ways later.

Lab 2

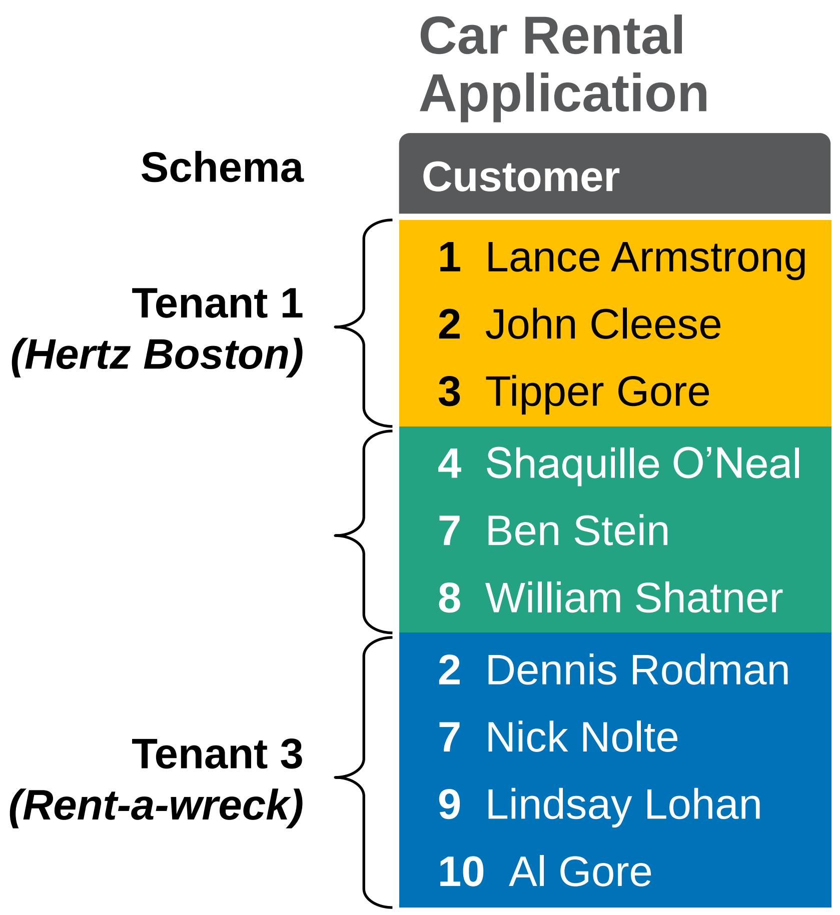
Defining tenants, domains, users

Continuing with multi-tenant concepts

Multi-tenancy: Data Access, Sharing

Tenant Groups

- Some tenants can share the same data/partition
- Employee access to shared customer list



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Multi-tenancy: Data Access, Sharing

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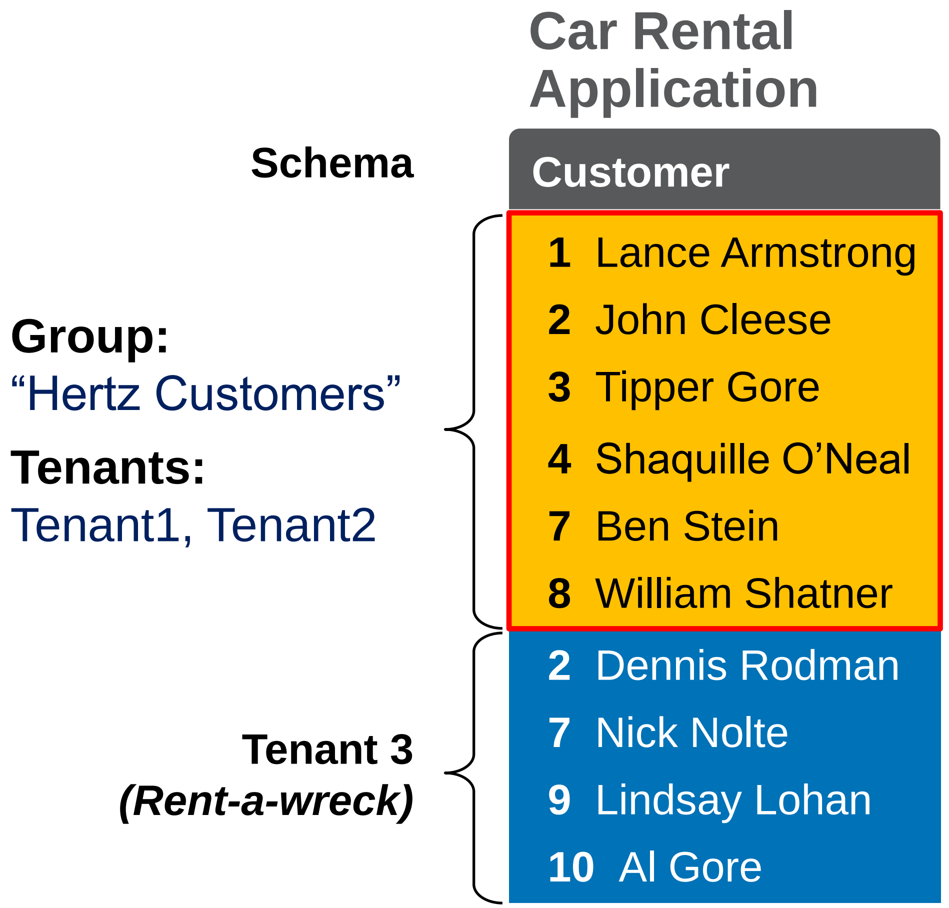
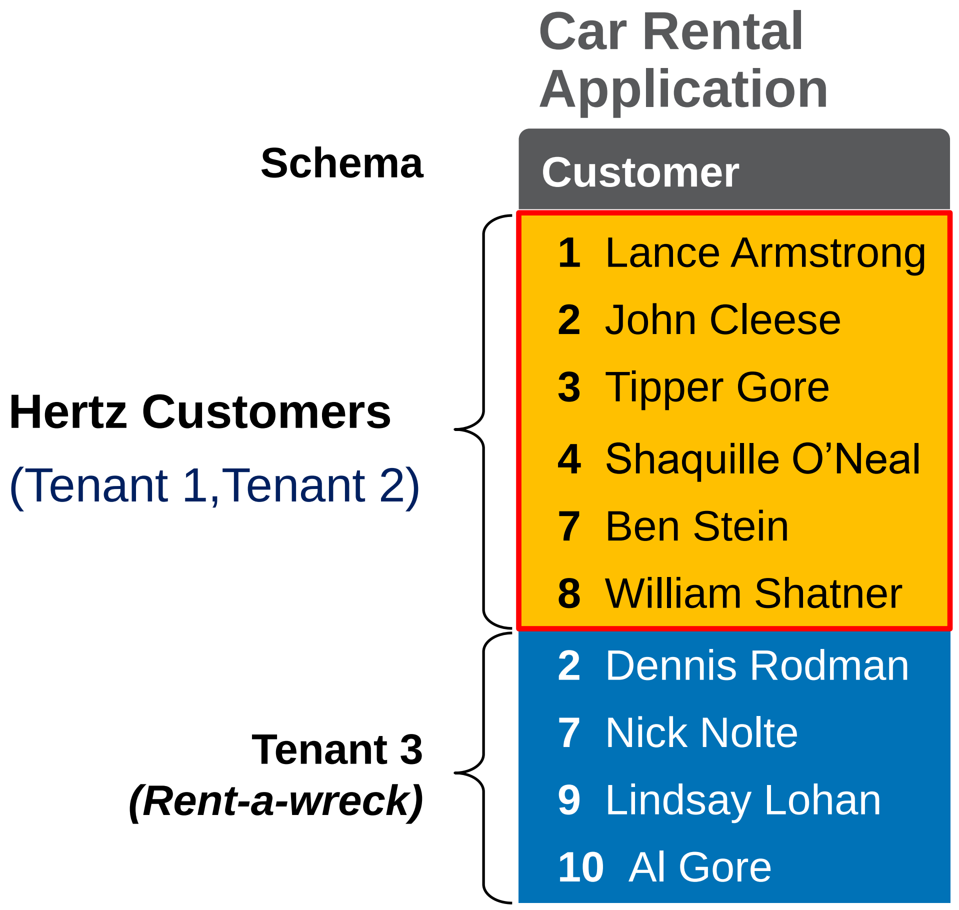


*Fictitious example

Multi-tenancy: Data Access, Sharing

Tenant Groups

- Some tenants can share the same data/partition
  - Employee access to shared customer list
- Data exists for the life of the group
  - e.g. Regional data
- Row identity associated with group
  - BUFFER-GROUP-ID()
  - BUFFER-GROUP-NAME()
- Group membership is per table



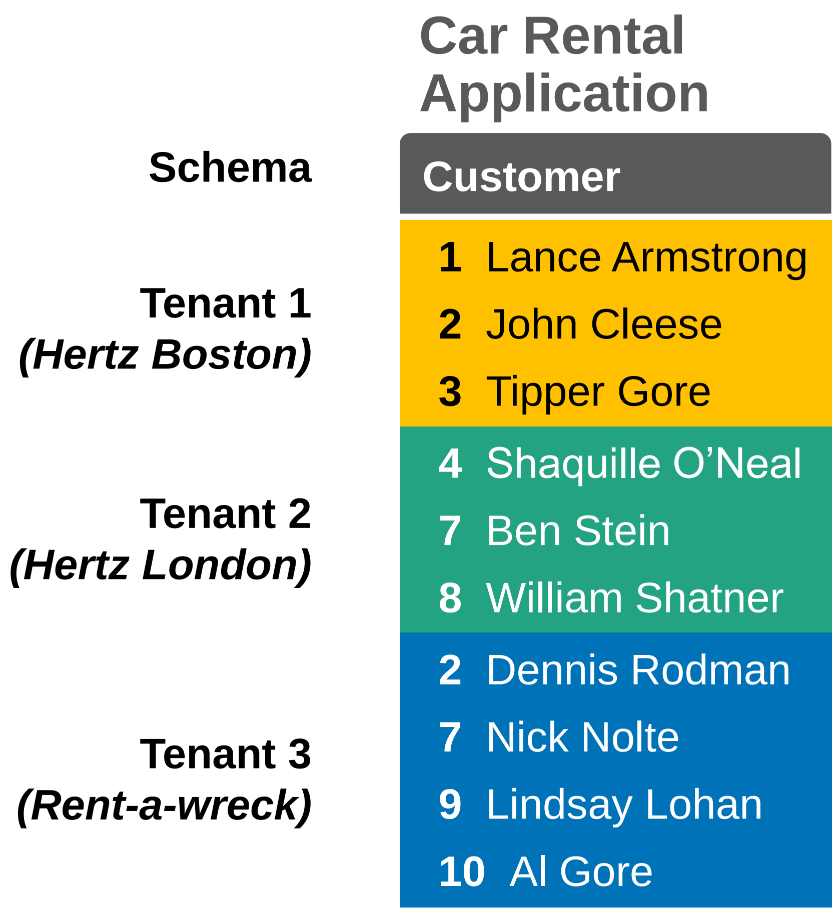
Customer	
1	Lance Armstrong
2	John Cleese
3	Tipper Gore
4	Shaquille O'Neal
7	Ben Stein
8	William Shatner
2	Dennis Rodman
7	Nick Nolte
9	Lindsay Lohan
10	Al Gore

*Fictitious example

Multi-tenancy: Data Model

The Data Model

- Multi-tenant objects
  - Tables and associated indexes & LOBs
  - Sequences
- Shared objects still available
  - Same as today
- Shared only, not multi-tenant
  - Triggers & stored procedures
  - Initial values
- Limits
  - Support for up to 32,767 tenants



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	7	Ben Stein
	8	William Shatner
Tenant 3 ***(Rent-a-wreck)***	**2**	Dennis Rodman
	7	Nick Nolte
	9	Lindsay Lohan
	10	Al Gore

*Fictitious example

Multi-tenancy: Tenant Provisioning

Managing Tenants

- Tenant creation: ABL, APIs, DDL & GUI
  - Programmatic tenant provisioning
  - Tenant partition creation optional
  - Tenant level activation/deactivation
- Identification (via "_Tenant" table)
  - Database specific tenant ID
  - User friendly name: "Hertz, Boston"
  - App specific ID (could be UUID)
- Resource access
  - Runtime security by user by tenant
  - Governors: Limit resource usage

Car Rental Application

Schema	**Customer**
Tenant 1 ***(Hertz Boston)***	**1** Lance Armstrong
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*Fictitious example

Multi-tenant Tables: Operational Features

Car Rental Application

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	8 William Shatner
	2 Dennis Rodman
Tenant 3 ***(Rent-a-wreck)***	**7** Nick Nolte
	9 Lindsay Lohan
	10 Al Gore

Operational Features

- Tenant partition maintenance
  - Tenant-specific object move
  - Add/drop tenants/objects
  - Data dump/load
  - .df support
  - Index maintenance tools
- Monitoring
  - Promon, VSTs
  - Analysis tools
  - .lg file (other log files)

Regular Tenant 4GL Queries

Note: 4GL Permissions

- 4GL user permissions for tables and columns work the same as before
  - CAN* permissions still apply : CAN-READ, CAN-WRITE, CAN-CREATE, CAN-DELETE, CAN-LOAD, CAN-DUMP
  - Only one set of permissions exists for tables, including multi-tenant tables
- All database users are subject to permission settings
  - Super-tenants users
  - Regular tenant users
  - Default tenant users
  - Administrators can change permissions, super-tenants by default cannot
- No need to say more.

4GL Queries

- Work the same as before
- For regular tenants, your code should work without change
- Effective tenant id determines what data is returned.
- What you see depends on who you are
- Same query returns different data for different tenants

```
for each customer:
    display custnum name.
end.
```

Lab 3

Looking at tenant data

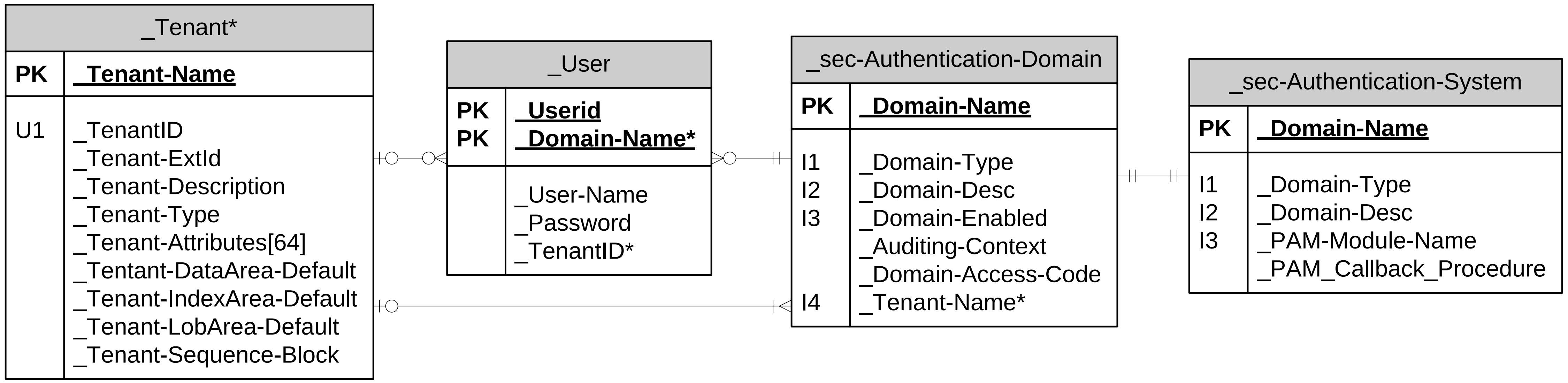
Now you must go to the principal's office

What data will you see ?
Depends who you are.
Database uses your identity to decide.

CLIENT-PRINCIPAL is basis for identity.

Multi-tenant Identity

The _User table (ABL & SQL) and friends



Creating CLIENT-PRINCIPAL tokens

Easy, peasy

```
DEFINE  VAR  hCP1  AS  HANDLE.
CREATE  Client-Principal  hCP1.
hCP1:Initialize(“Alice@avis").
hCP1:SEAL("password1").
```

Creating CLIENT-PRINCIPAL tokens 2

Easy, peasy

```
DEFINE  VAR  hCP2  AS  HANDLE.
CREATE  Client-Principal  hCP2.
hCP2:Initialize(“Bob@hertz").
hCP2:SEAL("password2")
```

And there are lots of properties you could set also

Client Principal Object Properties

SESSION-ID
USER-ID
DOMAIN-NAME
AUDIT-EVENT-CONTEXT
CLIENT-TTY
CLIENT-WORKSTATION
DB-LIST
DOMAIN-DESCRIPTION
DOMAIN-TYPE
INSTANTIATING-PROCEDURE

LOGIN-EXPIRATION-TIMESTAMP
LOGIN-HOST
LOGIN-STATE
QUALIFIED-USER-ID
ROLES
SEAL-TIMESTAMP
STATE-DETAIL
TYPE
LIST-PROPERTY-NAMES()
TENANT-ID()
TENANT-NAME()

Switching Identity with CLIENT-PRINCIPALs

```
SET-DB-CLIENT(hCP1).
/* now we are Alice */
FIND Customer WHERE name = "Alices Customer".
SECURITY-POLICY:SET-CLIENT (hCP2).
/* Now we are Bob */
CREATE Customer.
name = "Bobs Customer".
```

Other Ways to Establish Identity

With a userId@domainName, do:

```
SETUSERID(“alice@hertz”, “revolution").
```

or:

```
CONNECT –U alice@hertz –P revolution.
```

A CLIENT-PRINCIPAL token will be created for you automatically, under the covers.

Lab 4

Looking at tenant data

Using the Super-tenant

Why Do We Need Super-tenants?

- Sometimes you need to operate on data that belongs to other tenants
- Super-tenants exist to allow housekeeping cross-tenant tasks such as
  - Saas administration i.e. billing, moving tenants..
  - Migration from previous database versions
  - Handling of aggregate information across tenants
- Super-tenants have no data of their own
- Super-tenants have special ABL to allow them to:
  - Get access to regular tenant data
  - Execute legacy code

Super-tenant

- Special tenant, unlike any other
- Can read and write all tenants data
- Has users, like other tenants
  - alice@super, bob@super
- You will have to write NEW code for super tenant
- New 4GL functions for super tenant programming

Some New and a Few Modified 4GL Functions

IS-DB-MULTI-TENANT( ) function IS-MULTI-TENANT Property	**Check if multi-tenant**
SET-EFFECTIVE-TENANT( ) function GET-EFFECTIVE-TENANT-ID( ) function GET-EFFECTIVE-TENANT-NAME( ) function	**Set/get effective tenant**
TENANT-WHERE clause TENANT-NAME-TO-ID( ) function	**filter query by tenant**
CREATE statement FOR TENANT qualifier TENANT-ID( ) function	**convert name to number**
TENANT-NAME( ) function BUFFER-CREATE Method BUFFER-TENANT-ID( ) function BUFFER-TENANT-NAME( ) function BUFFER-TENANT-ID attribute BUFFER-TENANT-NAME attribute	**Identify tenant(s)**
REPOSITION query TO ROWID statement REPOSITION-TO-ROWID method	**Qualify ROWID with tenant**

SET-EFFECTIVE-TENANT () function

- Supertenant can become another tenant
- Can then read and write their data
  as if you were they

```
SET-EFFECTIVE-TENANT ("Avis").
for each customer:
    display custnum
    name.
end.
```

TENANT-WHERE query clause

- Super tenant can get all tenants data or some
- Add TENANT-WHERE clause to query

```
for each customer
    TENANT-WHERE tenant-id () > 0
    and tenant-name() < "M":
        display custnum
                    name.
end.
```

BUFFER-TENANT-NAME () function

- Tells you which tenant owns buffer contents

```
for each customer
    TENANT-WHERE tenant-id () > 0
    and tenant-name() < "M":

        display BUFFER-TENANT-NAME (customer)
                    custnum
                    name.
end.
```

Lab 5

Let's play super-tenant

Migration of Existing Data

How can we get our existing data organized (moved) into the right tenants partitions?

Default Tenant

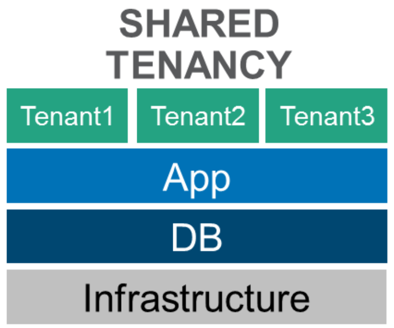
- Special tenant, unlike any other
- NOT intended for general use
- Has tenant id zero and default partition(s)
- Purpose: enable conversion of existing data
- Owns data when you conv1011 and mark tables with data as multi-tenant
- We assume
  - you will move the data
  - code to move data will be super tenant code
- Once data are moved, default tenant has nothing

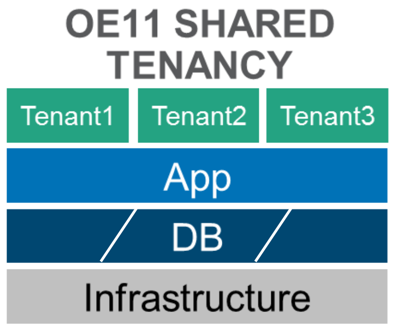
Default Tenant

- I lied. But only a little.
- The default tenant can access regular shared tables
- All users belong to default tenant when database is not multi-tenant enabled

  10.2 and earlier databases are not multi-tenant

Multi-tenant Tables: Data Migration with DIY Tenant ID Column





Schema

Default Partition

Customer		
1	**1**	Lance Armstrong
1	**2**	John Cleese
1	**3**	Tipper Gore
2	**4**	Shaquille O'Neal
2	**7**	Ben Stein
2	**8**	William Shatner
3	**2**	Dennis Rodman
3	**7**	Nick Nolte
3	**9**	Lindsay Lohan
3	**10**	Al Gore

- Enable multi-tenancy on existing db
- Mark existing table as multi-tenant table
- Data in default tenant partition
- Set super-tenant identity
- Move data
- Truncate empty partition

Moving the Data with DIY Tenant ID Column

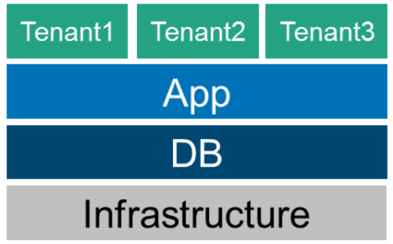
```
DEFINE BUFFER bCust FOR cust.
FOR EACH Cust WHERE Cust.tenant-id = 1

    TENANT-WHERE BUFFER-TENANT-ID(Cust)=0:
    CREATE bCust USE-TENANT 1.

    BUFFER-COPY Cust TO bCust.
    DELETE Cust.
END.
```

Moving the Data with DIY Tenant ID Column

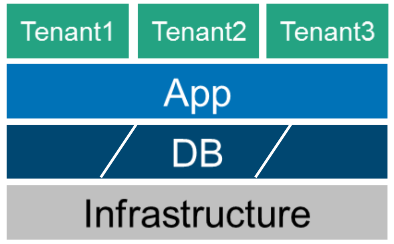
```
DEFINE BUFFER bCust FOR customer.
FOR EACH customer:
    FIND myTenant WHERE
         myTenant.tenantId = customer.tenantId.
    SET-EFFECTIVE-TENANT (myTenant.Name).
    CREATE bCust.
    BUFFER-COPY customer TO bCust.
    DELETE customer.
END.
```

Multi-tenant Tables: Data Migration from DIY Tenant ID Column

SHARED TENANCY



OE11 SHARED TENANCY



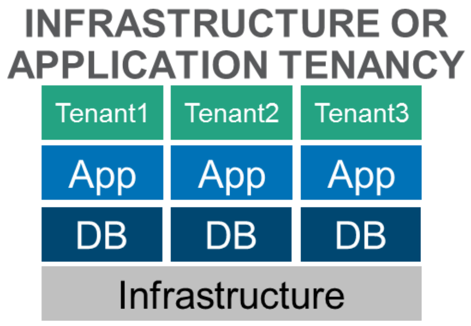
Customer		
2	7	Ben Stein
3	7	Nick Nolte
3	9	Lindsay Lohan
3	10	Al Gore

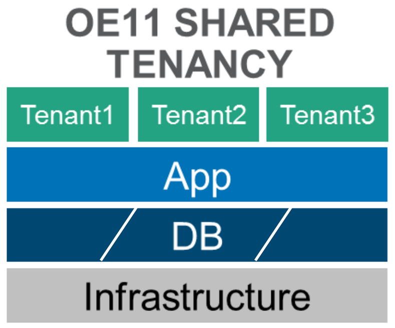
```
SETUSERID "alice@hertz1".
FOR EACH customer:
DISPLAY customer.
```

NOTE: Existing tenant column remains but is no longer needed for new multi-tenant queries.

Schema	Customer
Tenant 1 *(Hertz)*	1 Lance Armstrong
	2 John Cleese
	3 Tipper Gore
Tenant 2 *(Hertz)*	4 Shaquille O'Neal
	7 Ben Stein
	8 William Shatner
Tenant 3 *(Rent-a-wreck)*	2 Dennis Rodman
	7 Nick Nolte
	9 Lindsay Lohan
	10 Al Gore

Multi-tenant Tables: Data Migration with Database per Tenant





DB #1
(Hertz Boston)

Customer	
1	Lance Armstrong
2	John Cleese
3	Tipper Gore

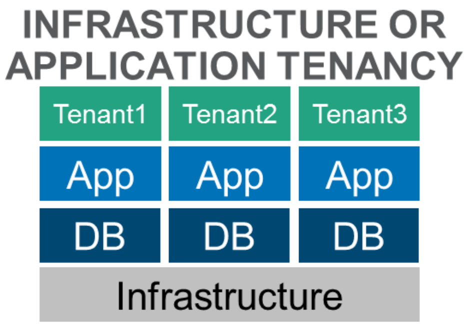
DB #2
(Hertz London)

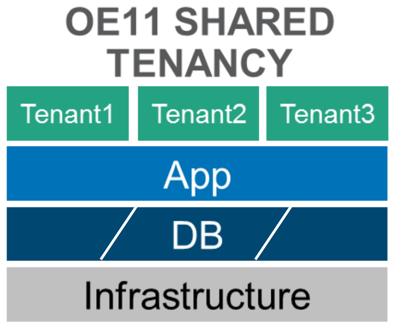
Customer	
4	Shaquille O’Neal
7	Ben Stein
8	William Shatner

DB #3
(R.W.)

Customer	
2	Dennis Rodman
7	Nick Nolte
9	Lindsay Lohan
10	Al Gore

Multi-tenant Tables: Data Migration with Database per Tenant





DB #1
(Hertz Boston)

Customer
1 Lance Armstrong
2 John Cleese
3 Tipper Gore

DB #2
(Hertz London)

Customer
4 Shaquille O'Neal
7 Ben Stein
8 William Shatner

DB #3
(R.W.)

Customer
2 Dennis Rodman
7 Nick Nolte
9 Lindsay Lohan
10 Al Gore

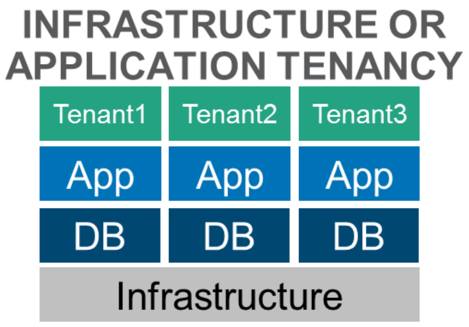
- Create **new** multi-tenant db
  - Can convert an existing one
  - Add tenants
  - Load multi-tenant schema
- Dump from current

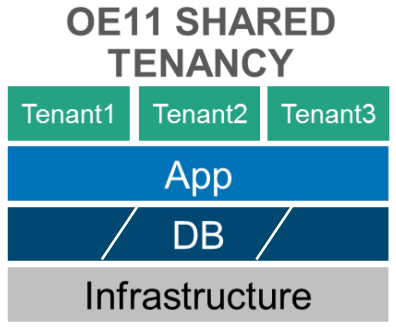
```
proutil  DB1 –C dump customer
```

- Load to new

```
proutil  MTdb –C load customer tenant  hertz2
```

Multi-tenant Tables: Data Migration with Database per Tenant





DB #1 *(Hertz)*

Customer	
1	Lance Armstrong
2	John Cleese
3	Tipper Gore

DB #2 *(Hertz)*

Customer	
4	Shaquille O'Neal
7	Ben Stein
8	William Shatner

DB #3 *(R.W.)*

Customer	
2	Dennis Rodman
7	Nick Nolte
9	Lindsay Lohan
10	Al Gore

Schema	Customer	
Tenant 1 *(Hertz)*	1	Lance Armstrong
	2	John Cleese
	3	Tipper Gore
Tenant 2 *(Hertz)*	4	Shaquille O'Neal
	7	Ben Stein
	8	William Shatner
Tenant 3 *(Rent-a-wreck)*	2	Dennis Rodman
	7	Nick Nolte
	9	Lindsay Lohan
	10	Al Gore

Benefits of “the best thing since sliced bread”

Simplifies development

- Minimal application changes
- No tenant-based customizations for queries or other data access

Eases deployment

- Tenant access to data is transparent, based on identity
- Tenants can be quickly and efficiently added, removed, and managed

Decreases maintenance overhead

- Fewer databases to manage, better resource utilization
- Tenant-based utilities and tools make maintenance tasks easier

Maintains security of tenant data

- Physical separation within database
- Tenant authentication required for data access

All Questions answered

PROGRESS