Association and Collection Mapping

Originals of Slides and Source Code for Examples:
http://courses.coreservlets.com/Course-Materials/hibernate.html

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Topics in This Section

- Understand Collection and Association relationships
- See how to realize relationships in Java and databases
- Walk through the Hibernate approach of mapping both Collections and Associations.

Relationships

Relationship Types

- **Association**
  - Mapping relationships between two objects
  - Example
    - Account and AccountOwner
- **Collection**
  - Collection of values representing individual pieces of data
  - Example
    - Map of holidays
    - String array of months

Relationship Dimensions

- **Relationships between entities can exist in multiple ways**
  - Multiplicity
    - How many on each side of the relationship?
  - Directionality
    - From which side(s) of the relationship can you access the other?
- **A single object may have multiple relationships**

Relationship Multiplicity

- **One-to-Many**
  - A *single* Account has *many* Transactions
  - Reverse of a many-to-one relationship
- **Many-to-One**
  - *Multiple* Transactions belong to a *single* account
  - Reverse of a one-to-many relationship
- **One-to-One**
  - A *single* AccountOwner has a *single* HomeAddress
  - A *single* HomeAddress has a *single* AccountOwner
- **Many-to-Many**
  - *Multiple* Accounts have *multiple* AccountOwners
  - Often realized through two one-to-many relationships
    - A *single* Account has *multiple* AccountOwners
    - A *single* AccountOwner has *multiple* Accounts

Relationship Directionality

- **Unidirectional**
  - Can only traverse objects from one side of the relationship
  - Example: Account : Transaction
    - Given an Account object, can obtain related Transaction objects.
    - Given a Transaction object, cannot obtain related Account object.
- **Bidirectional**
  - Can traverse objects from both sides of the relationship
  - Example: Account : Transaction
    - Given an Account object, can obtain related Transaction objects.
    - Given a Transaction object, can obtain related Account object.

Realizing Relationships

Java vs. Database

- **Java**
  - Objects are inherently directional
    - An object has a reference/pointer to another object
  - Transition by walking a networked graph of object references
- **Database**
  - Relations are *not* inherently directional
    - A table can arbitrarily join its columns with columns of other tables (not just those keyed to)
  - Transition by joining tables together through joins/foreign keys

**Source: Java Persistence with Hibernate*

Relationships in Java

- **Object has an attribute referencing another related Object**
- **For 'Many' side, Collections API**
  - Set
    - No duplication allowed
    - Objects organized with or without order
  - Map
    - Duplicate values allowed, using different keys
    - Can be organized with or without order
  - List
    - Duplication allowed
    - Objects expected to be organized in an order
  - Arrays
    - Duplication allowed
    - Objects expected to be organized in an order
    - Strongly typed to particular object type, and lacks ability to resize

Relationships in Database

- **Record relationships can be realized using several techniques**
  - Denormalized table
    - Record repeated in same table, each time capturing different relationship data.
  - Foreign keys
    - Follow identifiers to related records on other tables
  - Join tables
    - Tables specifically setup to maintain a relationship between two identities (usually for M:M)
  - Ad hoc joins in a query
    - Arbitrary joins between columns relating data
- **Each technique has its pros/cons**

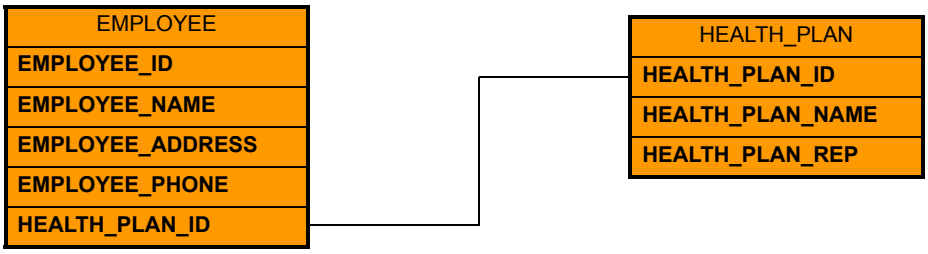
Relationships in Database

- **Denormalized Table**
  - Pros
    - Very fast
    - Easy to query against
  - Cons
    - Contains redundant data
    - Requires many nullable columns

ID	CUSTOMER_NAME	CUSTOMER_PHONE	CUSTOMER_ADDRESS	CONTRACTOR_NAME	CONTRACTOR_PHONE	CONTRACT_PRICE	START_DATE
3	CustomerOne	634-222-4572	100 Main Street	Home Depot	800-HOMEDEPOT	275	06-JUL-08 10.23.16.000000 PM
2	CustomerOne	634-222-4572	100 Main Street	Home Depot	800-HOMEDEPOT	4500	19-JUL-08 10.22.57.000000 PM
5	CustomerOne	634-222-4572	100 Main Street	Lowes	888-LOWES-SVC	300	05-SEP-08 10.23.49.000000 PM
1	CustomerOne	634-222-4572	100 Main Street	Home Depot	800-HOMEDEPOT	1000	19-JUN-08 10.22.37.000000 PM
7	CustomerTwo	470-987-9988	275 South Peach Avenue	Home Depot	800-HOMEDEPOT	349	26-AUG-08 10.24.37.000000 PM
6	CustomerTwo	470-987-9988	275 South Peach Avenue	Lowes	888-LOWES-SVC	600	16-JUL-08 10.24.18.000000 PM
8	CustomerTwo	470-987-9988	275 South Peach Avenue	Home Depot	800-HOMEDEPOT	975	07-SEP-08 10.24.46.000000 PM
4	CustomerTwo	470-987-9988	275 South Peach Avenue	Lowes	888-LOWES-SVC	150	14-AUG-08 10.23.33.000000 PM

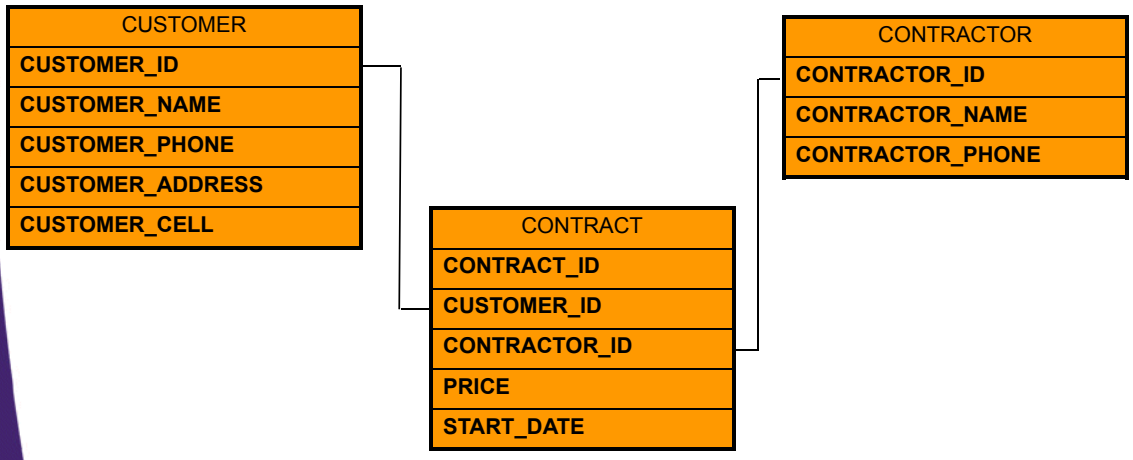
Relationships in Database

- **Foreign Keys**
  - Pros
    - Reduce redundancy
    - Better modeling of data
  - Cons
    - Slower than denormalized table
    - Slightly more complicated to query against



Relationships in Database

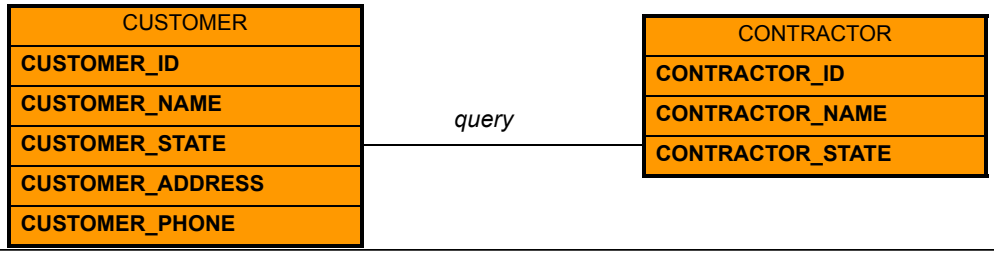
- **Join Tables**
  - Pros
    - Built on foreign key model, enables many:many relationships
  - Cons
    - Slower yet, and even more complex querying



Relationships in Database

- **Joins**
  - Pros
    - Allows for any possible query a user can think of without having to predefine the requirements in the schema design
  - Cons
    - No model enforcement
      - Can join 'age' and 'office floor' columns – but does it make sense?
    - Can be complicated/confusing to write; results may not appear as desired

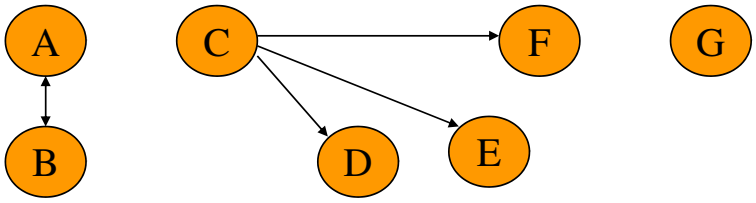
```
SELECT CONTRACTOR_NAME FROM CONTRACTOR WHERE CONTRACTOR_STATE = (SELECT
CUSTOMER_STATE FROM CUSTOMER WHERE CUSTOMER_NAME='JOHN SMITH');
```



Realizing Relationships with Hibernate

Domain object graph models

- **Hibernate represents domain object relationships through a graph model.**



- **Bidirectional relationships require graph model updates for objects on both sides**
  - Need to keep all in-memory objects up-to-date.
  - If Objects A and B have a bidirectional relationship, and Object B is added to Object A, need to make sure that Object A also gets added to Object B
  - Can cause complication when persisting the relationship
    - Which side should save the relationship?

Marking the Saving Side

"inverse" attribute

- Used for both 1:M/M:1 and M:M relationships
- For 1:M/M:1
  - Usually placed in the mapping file of the single object side of the relationship
- For M:M
  - One side of the relationship
  - If <idbag> used, must be on the non-idbag side

- **"property-ref" attribute**
  - Used for 1:1 relationships
    - Either side of the relationship, but only once

Setting up Relationships

1. **Determine your domain model relationships**
   - Define each as an association or collection
   - Identify the multiplicity between objects
   - Decide on the directionality
     - Does it need to be bidirectional?
2. **Define your relationship implementation types and add the Interface representation of each association/collection to appropriate domain objects** ***(List, Set, Array, etc…)***
3. **Create the mappings in the corresponding object mapping files**
4. **If bidirectional, optionally add bidirectional maintenance code**

Collections in Domain Objects

- **Must *always* use Interfaces**
  - Collection, List, Map, Set, etc…
- **Should be instantiated right away**
  - Not delegated to Constructor, Setter Method, etc…

```
List mylist = new ArrayList()
```

Mapping Multiplicity

- **1:M/M:1**
  - Example: EBiller has many EBills / EBill has one EBiller
  - On the 'one' side, map the Collection objects (EBiller)
    - `<one-to-many class="courses.hibernate.vo.EBill"/>`
  - On the 'many' side, map the single object (EBill)
    - `<many-to-one name="ebiller" column="EBILLER_ID" class="courses.hibernate.vo.EBiller" />`
- **M:M**
  - Example: Account has many EBillers / EBiller has many Accounts
  - On both sides, map the Collection objects
    - `<many-to-many column="ACCOUNT_ID" class="courses.hibernate.vo.Account" />`
    - `<many-to-many column="EBILLER_ID" class="courses.hibernate.vo.EBiller" />`
- **Only required on both sides if the relationship is bidirectional**

Mapping Multiplicity 1:1

- **UNINTUITIVE MAPPING!**
- **Example:**
  - EBill has at most one AccountTransaction
  - AccountTransaction has at most one EBill
  - Foreign key exists on the EBill table (to AccountTransaction)
- **In the NON-STORING Entity mapping file *(AccountTransaction)***
  -
```
<one-to-one name="ebill"
            class="courses.hibernate.vo.EBill"
            property-ref="accountTransaction"/>
```
- **In the STORING Entity mapping file *(EBill)***
  -
```
<many-to-one name="accountTransaction"
             column="ACCOUNT_TRANSACTION_ID"
             class="courses.hibernate.vo.AccountTransaction"/>
```
- **Enforce one-to-one in the database with unique constraints**
- **If storing foreign keys on both sides, use two many-to-one tags.**

Java-to-Database Through Hibernate

- **Association & Collection mapping tags practically identical**
- **Hibernate Collection Types**
  - <set>
    - Unordered/Ordered, requiring value column
  - <map>
    - Unordered/Ordered, requiring key and value columns
  - <list>
    - Ordered, requiring an index column on the referenced object table

Java-to-Database Through Hibernate

- <array>
  - Map to Java Type and Primitive Arrays
  - Ordered, requiring an index column on the referenced object table
- <bag>
  - No direct implementation available in Java
  - Unordered/ordered collection allowing duplicates
  - Realized through Collection/List
  - Requires value column
- <idbag>
  - Used for many-to-many relationships
  - Same as Bag, but with additional identifier column used for surrogate keys
  - Requires an ID Generator just like Entity classes

Association as <set>

- **Maps to a 'Set' interface**
  - Impls include HashSet, TreeSet, etc…
- **Can be optionally sorted**

EBiller has many EBills (1:M / M:1)

EBill Mapping

```
<many-to-one name="ebiller" column="EBILLER_ID"
             class="courses.hibernate.vo.EBiller" />
```

EBiller Mapping

```
<set name="ebills" inverse="true"
   sort="unsorted|natural|my.custom.MyComparator">
   <key column="EBILLER_ID" not-null="true"/>
   <one-to-many class="courses.hibernate.vo.EBill"/>
</set>
```

Association as <map>

- **Maps to a 'Map' interface**
  - Impls include HashMap, TreeMap, etc…
- **Must identify a column to be used for map key**
  - Can be 'column', or 'formula' (any sql expression)
- **Can be optionally sorted**

EBiller has many EBills (1:M / M:1)

EBill Mapping

```
<many-to-one name="ebiller" column="EBILLER_ID"
             class="courses.hibernate.vo.EBiller" />
```

EBiller Mapping

```
<map name="ebills" inverse="true"
  sort="unsorted|natural|my.custom.MyComparator">
  <key column="EBILLER_ID"/>
  <map-key column="EBILL_ID" type="long"/>
  <one-to-many class="courses.hibernate.vo.EBill"/>
</map>
```

Association as <list>

- **Maps to a 'List' interface**
  - Impls include ArrayList, LinkedList, etc…
- ***MUST* have a dedicated list-index column on table**
  - Sequential ordering of items for the parent specified
  - Skipped numbers result in Null values in list

EBiller has many EBills (1:M / M:1)

EBill Mapping

```
<many-to-one name="ebiller" column="EBILLER_ID"
             class="courses.hibernate.vo.EBiller" />
```

EBiller Mapping

```
 <list name="ebills" inverse="true" >
   <key column="EBILLER_ID" not-null="true"/>
   <list-index column="EBILLER_EBILL_NUMBER"/>
   <one-to-many class="courses.hibernate.vo.EBill"/>
</list>
```

Association as <array>

- **Like 'List', Arrays *MUST* have a dedicated list-index column on table**

EBiller has many EBills (1:M / M:1)

EBill Mapping

```
<many-to-one name="ebiller" column="EBILLER_ID"
             class="courses.hibernate.vo.EBiller" />
```

EBiller Mapping

```
<array name="ebillsArray" inverse="true">
   <key column="EBILLER_ID"/>
   <list-index column="EBILLER_EBILL_NUMBER"/>
   <one-to-many class="courses.hibernate.vo.EBill"/>
</array>
```

Association as <bag>

- **Must be mapped to a Collection or List Interface**
  - 'List' can be used in combination with 'order-by' to preserve order
- **Can be optionally sorted**

EBiller has many EBills (1:M / M:1)

EBill Mapping

```
<many-to-one name="ebiller" column="EBILLER_ID"
   class="courses.hibernate.vo.EBiller" />
```

EBiller Mapping

```
<bag name="ebills" inverse="true" order-by="DUE_DATE ASC">
   <key column="EBILLER_ID" not-null="true"/>
   <one-to-many class="courses.hibernate.vo.EBill"/>
</bag>
```

Association as <idbag>

- **Same as 'Bag' – but only used in many-to-many relationships**
  - Allows for mapping of surrogate keys on join table
  - Hibernate will set the id on the join table
  - Can ***NOT*** use idbag on both sides of the relationship! Non-idbag side must have inverse="true"
- **Can be optionally sorted**

EBiller has many Accounts / Account has many EBillers (M:M)

EBill Mapping

```
<bag name="accounts" table="ACCOUNT_EBILLER" inverse="true">
  <key column="EBILLER_ID"/>
  <many-to-many column="ACCOUNT_ID"
                class="courses.hibernate.vo.Account"/>
</bag>
```

Remember inverse=true on 'non-idbag' side?

Account Mapping

```
<idbag name="accounts" table="ACCOUNT_EBILLER"
       order-by="DUE_DATE ASC" >
   <collection-id column="ACCOUNT_EBILLER_ID" type="long">
        <generator class="native"/>
   </collection-id>
   <key column="EBILLER_ID"/>
   <many-to-many column="ACCOUNT_ID"
                 class="courses.hibernate.vo.AccountOwner" />
</idbag>
```

Collection Mapping

- **Can be used across all mapping types**
  - Just substitute relationship tag *(<one-to-many, <many-to-one> etc…)* with <element> tag
  - No inverse required (not an 'association')

Previously Shown Association EBiller Mapping (EBiller:EBill)

```
<bag name="ebills" inverse="true" order-by="DUE_DATE">
   <key column="EBILLER_ID" not-null="true"/>
   <one-to-many class="courses.hibernate.vo.EBill"/>
</bag>
```

Collection EBiller Mapping (stores *balances* across issued EBills)

```
<bag name="ebillBalances" table="EBILL"
     order-by="DUE_DATE">
   <key column="EBILLER_ID"/>
   <element column="BALANCE" type="double"/>
</bag>
```

Bidirectional Maintenance

- **Developers must maintain bidirectional associations in order to keep in-memory objects up-to-date**

```
aParent.getChildren().add(aChild);
aChild.setParent(aParent);
```

- **Hibernate recommends a strategy to ensure this process.**

Hibernate's Bidirectional Strategy

- **Maintain associations on a single side of the relationship**
- **Make 'setMySet()' protected**
- **Create 'addObject' method instead of object.getMySet().add(object);**
  - Within addObject(), set both relationships
- **p.120 of Java Persistence with Hibernate**

Example EBiller→EBill (1:M/M:1)

EBill (M:1)

```
protected void setEBiller(EBiller ebiller) {
   this.ebiller = ebiller;
}
```

EBiller (1:M)

```
public void addEBill(EBill ebill) {
   if (!ebill.getEBiller().equals(this) {
        ebill.getEBiller().getEBills().remove(ebill);
   }
   ebill.setEBiller(this);
   this.ebills.add(ebill);
}
```

Modified Hibernate Strategy

- **Hibernate strategy might not solve all cases**
  - Related objects are required to be in the same package
  - Developers need to remember which object to call
- **Modified Hibernate Strategy**
  - Maintain relationship on either side
  - Slightly varying implementations required for different relationship types
    - 1:1
    - M:M
      - Collections on both sides
    - 1:M/M:1
      - has single object that can potentially be null
    - Collections should always be instantiated (early) – so never null

Modified Bidirectional Strategy 1:1

- **Need to handle potential null object on each side**
  - Objects might not be initialized

Example: EBill has one Transaction / Transaction has one EBill

EBill Set Method

```
public void setTransaction(Transaction transaction) {
  this.transaction = transaction;
  if (transaction != null &&
      (transaction.getEbill() == null ||
       !transaction.getEbill().equals(this))) {
    transaction.setEbill(this);
  }
}
```

Transaction Set Method

```
public void setEbill(EBill ebill) {
  this.ebill = ebill;
  if (ebill != null &&
      (ebill.getTransaction() == null ||
       !ebill.getTransaction().equals(this))) {
    ebill.setTransaction(this);
  }
}
```

Modified Bidirectional Strategy M:M

- **Protected Setters for Collections on both sides**
- **Do not need to handle null checks**
  - Collections should be initialized early

Example: Account has many EBillers / EBiller has many Accounts

EBiller Set Method

```
protected void setAccounts(List<Account> accounts) {
  this.accounts = accounts;
}
```

EBiller Add Method

```
public void addAccount(Account account){
  this.accounts.add(account);
  if (!account.getEbillers().contains(this))  {
    account.addEbiller(this);
  }
}
```

EBiller Remove Method

```
public void removeAccount(Account account) {
     this.accounts.remove(account);
     if (account.getEbillers().contains(this)) {
          account.removeEbiller(this);
     }
}
```

Modified Bidirectional Strategy M:M

- **Protected Setters for Collections on both sides**
- **Do not need to handle null checks**
  - Collections should be initialized early

Example: Account has many EBillers / EBiller has many Accounts

Account Setter

```
protected void setEbillers(List<EBiller> ebillers) {
  this.ebillers = ebillers;
}
```

Account Add Method

```
public void addEbiller(EBiller ebiller) {
  this.ebillers.add(ebiller);
  if (!ebiller.getAccounts().contains(this)) {
    ebiller.addAccount(this);
  }
}
```

Account Remove Method

```
public void removeEbiller(EBiller ebiller) {
  this.ebillers.remove(ebiller);
  if (ebiller.getAccounts().contains(this)) {
    ebiller.removeAccount(this);
  }
}
```

Modified Bidirectional Strategy 1:M

- **Protected Setter for Collection**
- **Need to handle null check on non-Collection side**
  - Object may not have been initialized

Example: EBiller has many EBills / EBill has one EBiller

EBill Setter

```
public void setEbiller(EBiller ebiller) {
  this.ebiller = ebiller;
  if (ebiller != null && !ebiller.getEbills().contains(this)) {
    ebiller.addEbill(this);
  }
}
```

Modified Bidirectional Strategy 1:M

- **Protected Setter for Collection**
- **Need to handle null check on non-Collection side**
  - Object may not have been initialized

Example: EBiller has many EBills / EBill has one EBiller

EBiller Set Method

```
protected void setEbills (SortedSet<EBill> ebills) {
  this.ebills = ebills;
}
```

EBiller Add Method

```
public void addEbill(EBill ebill) {
  this.ebills.add(ebill);
  if (!ebill.getEBiller().equals(this) {
    ebill.getEBiller().getEBills().remove(ebill)
    ebill.setEbiller(this);
  }
}
```

EBiller Remove Method

```
public void removeEbill(EBill ebill) {
  ebills.remove(ebill);
  if (ebill.getEbiller().equals(this)) {
    ebill.setEbiller(null);
  }
}
```

Bidirectional Concern

- **Recursive Issue**
  - Objects commonly refer to attributes contained within themselves during method execution
  - Can result in StackOverflowException
    - hashCode()
    - toString()
    - equals()
    - Hibernate's strategy for setting bidirectionality
  - Hibernate recommends NOT using associate objects in these methods
  - For 1:M, on the many side, set 'access by field' on the <many-to-one> tag.
- **In all, bidirectionality can be powerful, but complicated and overly involved to handle**
  - Ask yourself, does this really *need* to be bidirectional?

Additional M:M Options

Many-to-Many Option

- **Hibernate actually recommends *not* using traditional many-to-many relationships**
- **Proposes use of "Intermediate Associations"**
  - Relationships often have data directly tied to them. If not, likely to later, so might as well start with this approach
  - "Intermediate" object to map the relationship
  - Can be accomplished in one of two ways
    - Composite element
    - Entity class

Intermediate Association: Composite

- **Customer:Contractor (M:M)**
- **Parent object contains a Collection of "Contract" objects**
  - Each "Contract" object contains the Customer, Contractor, and data about the relationship *(start date, contract price, etc…)*

MAPPING FOR CUSTOMER

```
<set name="contracts" table="CUSTOMER_CONTRACTOR">
  <key column="customer_id"/>
  <composite-element class="Contract">
    <parent name="customer"/>
    <many-to-one name="contractor" column="contractor_id"
                 not-null="true"   class="Contractor"/>
    <property name="startDate" column="start_date" type="date"/>
    <property name="price" column="price" type="string"/>
  </composite-element/>
</set>
```

Intermediate Association: Composite

- **Advantages**
  - Lifecycle of composite element is tightly coupled to parent object
    - To create an association, add a new Contract to the Collection

```
Contract aContract =
          new Contract(aCustomer, aContractor);
aCustomer.getContracts().add(aContract);
```

    - To delete, remove from Collection
      - `aCustomer.getContracts().remove(aContract);`
- **Disadvantages**
  - Bidirectional navigation is impossible
    - Composite element only exists within the context of the parent class
    - However – can write a query to retrieve the objects you need

Intermediate Association: Entity Class

- **Customer:Contractor (M:M)**
  - Realized through two one-to-many relationships
- **Each side contains a Collection of Contract objects**
  - Each Contract object contains the Customer, Contractor, and data about the relationship *(start date, contract price, etc…)*

MAPPING FOR CUSTOMER

```
<set name="contracts" inverse="true">
   <key column="customer_id"/>
   <one-to-many class="Contract"/>
</set>
```

MAPPING FOR CONTRACTOR

```
<set name="contracts" inverse="true">
   <key column="constractor_id"/>
   <one-to-many class="Contract"/>
</set>
```

Intermediate Association: Entity Class

MAPPING FOR CONTRACT *(Relationship Entity)*

```
<class name="Contract" table="CUSTOMER_CONTRACTOR"
       mutable="false">
  <id name="contractId" column="CUSTOMER_CONTRACTOR_ID">
    <generator class="native"/>
  </id>
  <property name="startDate" column="start_date"
            type="date"/>
  <property name="price" column="price"
            type="string"/>
  <many-to-one name="customer" column="customer_id"
               not-null="true" update="false"/>
  <many-to-one name="contractor" column="contractor_id"
               not-null="true"   update="false"/>
</class>
```

NOTICE CONTRACT HAS ITS OWN ID – (Think "Entity")

Intermediate Association: Entity Class

- **Advantages**
  - Bidirectional capabilities
    - Both objects obtain other through Contract

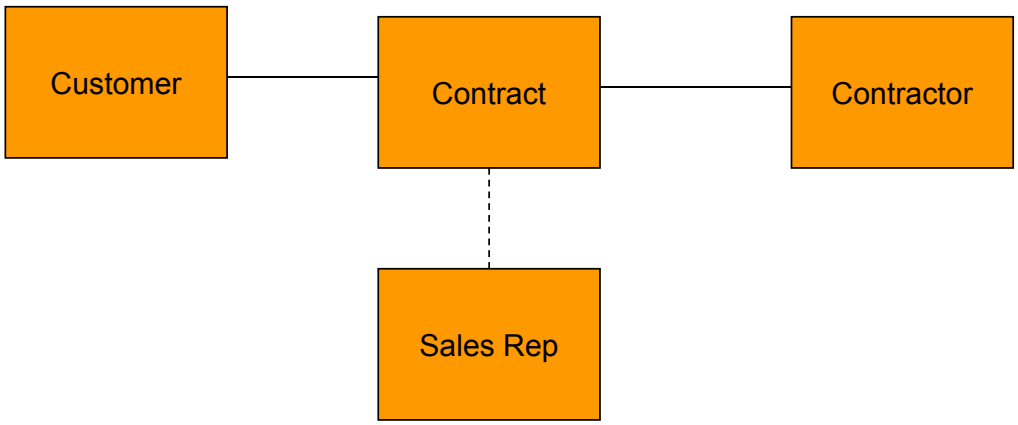
      `aContractor.getContracts()`

      `aCustomer.getContracts()`
- **Disadvantages**
  - No direct access to collection on other side (need to loop through all the Contract objects to build collection)
  - More complex code needed to manage the Contract entity instance to create and remove associations
    - Requires additional infrastructure code
      - Entity Class (Contract)
      - Identifier
    - Intermediate class has to be saved and deleted independently to create links between objects

```
Contract aContract = newContract(aCustomer.getCustomerId(),
    aContractor.getContractorId());
session.save(aContract);
```

Ternary Relationships

- Relationship across three objects
- Leverage the Intermediate Association to include a reference to an additional third Entity



Ternary Relationships

MAPPING FOR CONTRACT *(Relationship Entity)*

```
<class name="Contract" table="CUSTOMER_CONTRACTOR"
       mutable="false">
  <id name="contractId" column="CUSTOMER_CONTRACTOR_ID">
    <generator class="native"/>
  </id>
  <property name="startDate" column="start_date"
            type="date"/>
  <property name="price" column="price" type="string"/>
  <many-to-one name="customer" column="customer_id"
               not-null="true" update="false"/>
  <many-to-one name="contractor" column="contractor_id"
               not-null="true"   update="false"/>
  <many-to-one name="salesRep" column="sales_rep_id"
               not-null="true" update="false"/>
</class>
```

Wrap-up

Summary

In this lecture, we:

- **Learned that Associations are relationships between Entity classes and Collections are just groupings of scalar data**
- **Looked at the way Java and databases realize relationships**
  - Java: Object references
  - Databases: Denormalized tables, foreign keys, join tables, and ad hoc joins
- **Walked through the ways to realize relationships with Hibernate**
  - Setting up the mapping files
  - Coding to Interfaces
- **Discussed some Hibernate recommended approaches using an 'intermediate' object to realize M:M and ternary relationships**

Preview of Next Sections

- Understand the differences between Component & Entity classes
- Learn how to map Components
- Walk through ways of realizing inheritance

Questions?