Drawing a Design Diagram using the Business Object Notation (BON)

EECS3311 A & E: Software Design
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Learning Objectives

- Purpose of a **Design Diagram**: an *Abstraction* of Your Design
- Architectural Relation: ***Client-Supplier*** vs. ***Inheritance***
- Presenting a class: Compact vs. Detailed
- Denoting a Class or Feature: Deferred vs. Effective

Why a Design Diagram?

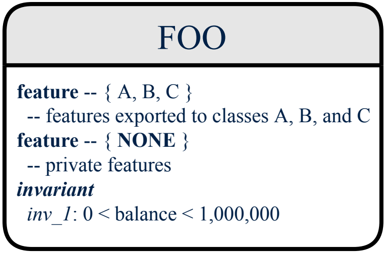
- **SOURCE CODE** is **not** an appropriate form for communication.
- Use a **DESIGN DIAGRAM** showing *selective* sets of important:
  - clusters (i.e., packages)
  - classes
    [deferred vs. effective]
    [generic vs. non-generic]
  - architectural relations
    [client-supplier vs. inheritance]
  - routines (queries and commands)
    [deferred vs. effective vs. redefined]
  - ***contracts***
    [precondition vs. postcondition vs. class invariant]
- Your design diagram is called an *abstraction* of your system:
  - Being *selective* on what to show, filtering out **irrelevant details**
  - Presenting ***contractual specification*** in a ***mathematical form*** (e.g., $\forall$ instead of `across ... all ... end`).

Classes: Detailed View vs. Compact View (1)

- $\boxed{\text{Detailed view}}$ shows a selection of:
  - **features** (queries and/or commands)
  - **contracts** (class invariant and feature pre-post-conditions)
  - Use the detailed view if readers of your design diagram ***should know*** such details of a class.
    e.g., Classes critical to your design or implementation
- $\boxed{\text{Compact view}}$ shows only the class name.
  - Use the compact view if readers ***should not be bothered with*** such details of a class.
    e.g., Minor "helper" classes of your design or implementation
    e.g., Library classes (e.g., `ARRAY`, `LINKED_LIST`, `HASH_TABLE`)

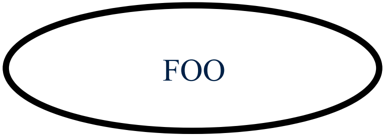
Classes: Detailed View vs. Compact View (2)

Detailed View



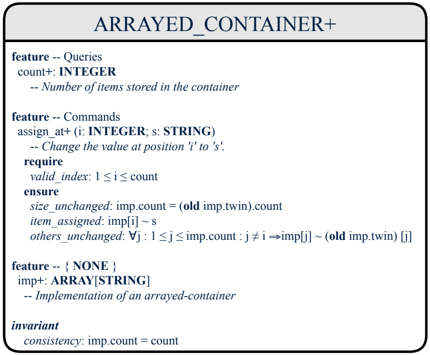
```
feature -- { A, B, C }
  -- features exported to classes A, B, and C
feature -- { NONE }
  -- private features
invariant
  inv_1: 0 < balance < 1,000,000
```

Compact View



Contracts: Mathematical vs. Programming

- When presenting the detailed view of a class, you should include *contracts* of features which you judge as ***important***.
- Consider an array-based linear container:

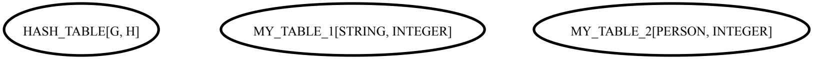


```
ARRAYED_CONTAINER+

feature -- Queries
 count+: INTEGER
    -- Number of items stored in the container

feature -- Commands
 assign_at+ (i: INTEGER; s: STRING)
    -- Change the value at position 'i' to 's'.
   require
    valid_index: 1 ≤ i ≤ count
   ensure
    size_unchanged: imp.count = (old imp.twin).count
    item_assigned: imp[i] ~ s
    others_unchanged: ∀j : 1 ≤ j ≤ imp.count : j ≠ i ⇒imp[j] ~ (old imp.twin) [j]

feature -- { NONE }
 imp+: ARRAY[STRING]
   -- Implementation of an arrayed-container

invariant
   consistency: imp.count = count
```

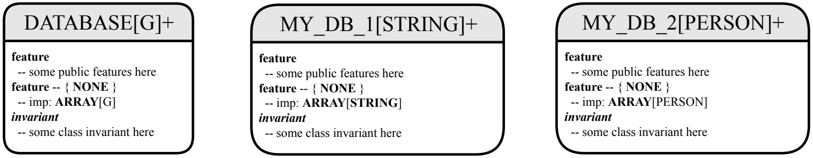
- A ***tag*** should be included for each contract.
- Use ***mathematical*** symbols (e.g., ∀, ∃, ≤) instead of ***programming*** symbols (e.g., `across ... all ...`, `across ... some ...`, <=).

Classes: Generic vs. Non-Generic

- A class is *generic* if it declares **at least one** type parameters.
  - Collection classes are generic: `ARRAY[G]`, `HASH_TABLE[G, H]`, *etc.*
  - Type parameter(s) of a class may or may not be ***instantiated***:



  - If necessary, present a generic class in the detailed form:



```
DATABASE[G]+
feature
  -- some public features here
feature -- { NONE }
  -- imp: ARRAY[G]
invariant
  -- some class invariant here
```

```
MY_DB_1[STRING]+
feature
  -- some public features here
feature -- { NONE }
  -- imp: ARRAY[STRING]
invariant
  -- some class invariant here
```

```
MY_DB_2[PERSON]+
feature
  -- some public features here
feature -- { NONE }
  -- imp: ARRAY[PERSON]
invariant
  -- some class invariant here
```

- A class is *non-generic* if it declares **no** type parameters.

Deferred vs. Effective

$\boxed{\text{Deferred}}$ means ***unimplemented*** (≈ **abstract** in Java)

$\boxed{\text{Effective}}$ means ***implemented***

Classes: Deferred vs. Effective

- A ***deferred** class* has **at least one** feature ***unimplemented***.
  - A *deferred class* may only be used as a ***static*** type (for declaration), but cannot be used as a ***dynamic*** type.
  - e.g., By declaring `list:` ***LIST[INTEGER]*** (where `LIST` is a ***deferred*** class), it is invalid to write:
    - **create** `list.make`
    - **create** {***LIST[INTEGER]***} `list.make`
- An ***effective** class* has **all** features ***implemented***.
  - An *effective class* may be used as both ***static*** and ***dynamic*** types.
  - e.g., By declaring `list:` ***LIST[INTEGER]***, it is valid to write:
    - **create** {***LINKED_LIST[INTEGER]***} `list.make`
    - **create** {***ARRAYED_LIST[INTEGER]***} `list.make`

    where `LINKED_LIST` and `ARRAYED_LIST` are both ***effective*** descendants of `LIST`.

Features: Deferred, Effective, Redefined (1)

A ***deferred** feature* is declared with its ***header*** only (i.e., name, parameters, return type).

- The word "***deferred***" means a descendant class would later implement this feature.
- The resident class of the ***deferred*** feature must also be ***deferred***.

```
deferred class
  DATABASE[G]
feature -- Queries
  search (g: G): BOOLEAN
      -- Does item 'g' exist in database?
    deferred end
end
```

Features: Deferred, Effective, Redefined (2)

- An ***effective** feature* ***implements*** some inherited deferred feature.

```
class
  DATABASE_V1[G]
inherit
  DATABASE[G]
feature -- Queries
  search (g: G): BOOLEAN
      -- Perform a linear search on the database.
    do end
end
```

- A descendant class may still later ***re-implement*** this feature.

Features: Deferred, Effective, Redefined (3)

- A ***redefined** feature* ***re-implements*** some inherited effective feature.

```
class
  DATABASE_V2[G]
inherit
  DATABASE_V1[G]
      redefine search end
feature -- Queries
  search (g: G): BOOLEAN
     -- Perform a binary search on the database.
    do end
end
```

- A descendant class may still later ***re-implement*** this feature.

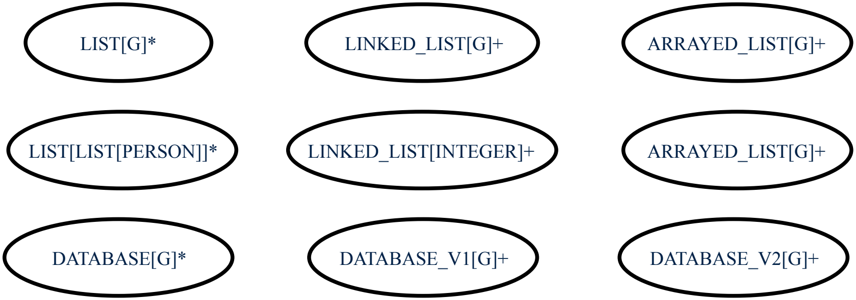
Classes: Deferred vs. Effective (2.1)

Append a star * to the name of a ***deferred*** class or feature.

Append a plus **+** to the name of an ***effective*** class or feature.

Append two pluses **++** to the name of a ***redefined*** feature.

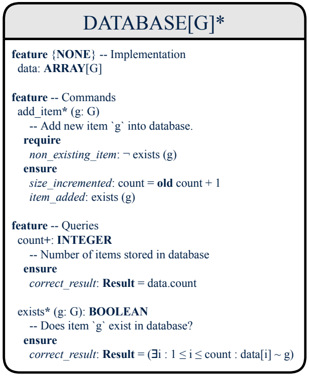
- Deferred or effective classes may be in the compact form:



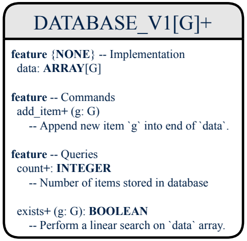
Classes: Deferred vs. Effective (2.2)

Append a star $\star$ to the name of a ***deferred*** class or feature.
Append a plus **+** to the name of an ***effective*** class or feature.
Append two pluses **++** to the name of a ***redefined*** feature.

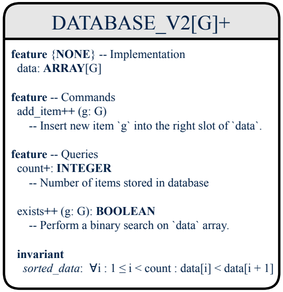
- Deferred or effective classes may be in the detailed form:



```
DATABASE[G]*

feature {NONE} -- Implementation
 data: ARRAY[G]

feature -- Commands
 add_item* (g: G)
    -- Add new item `g` into database.
   require
    non_existing_item: ¬ exists (g)
   ensure
    size_incremented: count = old count + 1
    item_added: exists (g)

feature -- Queries
 count+: INTEGER
    -- Number of items stored in database
   ensure
    correct_result: Result = data.count

 exists* (g: G): BOOLEAN
    -- Does item `g` exist in database?
   ensure
    correct_result: Result = (∃i : 1 ≤ i ≤ count : data[i] ~ g)
```



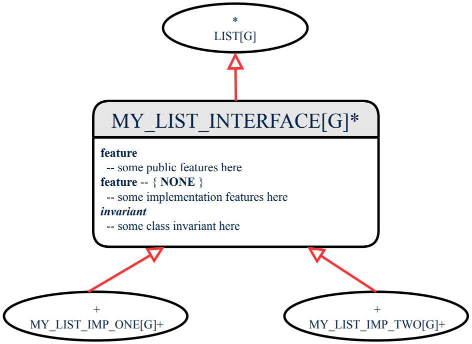
```
DATABASE_V1[G]+

feature {NONE} -- Implementation
 data: ARRAY[G]

feature -- Commands
 add_item+ (g: G)
    -- Append new item `g` into end of `data`.

feature -- Queries
 count+: INTEGER
    -- Number of items stored in database

 exists+ (g: G): BOOLEAN
    -- Perform a linear search on `data` array.
```



```
DATABASE_V2[G]+

feature {NONE} -- Implementation
 data: ARRAY[G]

feature -- Commands
 add_item++ (g: G)
    -- Insert new item `g` into the right slot of `data`.

feature -- Queries
 count+: INTEGER
    -- Number of items stored in database

 exists++ (g: G): BOOLEAN
    -- Perform a binary search on `data` array.

 invariant
  sorted_data: ∀i : 1 ≤ i < count : data[i] < data[i + 1]
```

Class Relations: Inheritance (1)

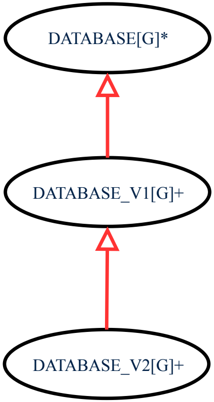
- An *inheritance hierarchy* is formed using ***red arrows***.
  - Arrow's ***origin*** indicates the ***child***/***descendant*** class.
  - Arrow's ***destination*** indicates the ***parent***/***ancestor*** class.
- You may choose to present each class in an inheritance hierarchy in either the detailed form or the compact form:

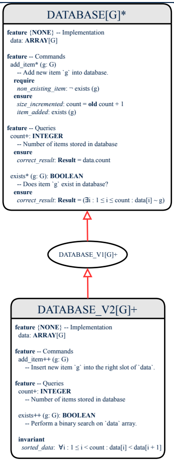


Class Relations: Inheritance (2)

More examples (emphasizing different aspects of `DATABASE`):

Inheritance Hierarchy	Features being (Re-)Implemented





```
DATABASE[G]*

feature {NONE} -- Implementation
  data: ARRAY[G]

feature -- Commands
  add_item* (g: G)
      -- Add new item `g` into database.
    require
      non_existing_item: ¬ exists (g)
    ensure
      size_incremented: count = old count + 1
      item_added: exists (g)

feature -- Queries
  count+: INTEGER
      -- Number of items stored in database
    ensure
      correct_result: Result = data.count

  exists* (g: G): BOOLEAN
      -- Does item `g` exist in database?
    ensure
      correct_result: Result = (∃i : 1 ≤ i ≤ count : data[i] ~ g)
```

```
DATABASE_V2[G]+

feature {NONE} -- Implementation
  data: ARRAY[G]

feature -- Commands
  add_item++ (g: G)
      -- Insert new item `g` into the right slot of `data`.

feature -- Queries
  count+: INTEGER
      -- Number of items stored in database

  exists++ (g: G): BOOLEAN
      -- Perform a binary search on `data` array.

  invariant
    sorted_data:  ∀i : 1 ≤ i < count : data[i] < data[i + 1]
```

Class Relations: Client-Supplier (1)

- A $\boxed{\text{client-supplier (CS) relation}}$ exists between two classes: one (the ***client***) uses the service of another (the ***supplier***).
- Programmatically, there is CS relation if in class `CLIENT` there is a variable declaration $\boxed{\texttt{s1: SUPPLIER}}$.
    - A variable may be an attribute, a parameter, or a local variable.
- A ***green arrow*** is drawn between the two classes.
    - Arrow's ***origin*** indicates the ***client*** class.
    - Arrow's ***destination*** indicates the ***supplier*** class.
    - Above the arrow there should be a *label* indicating the **supplier name** (i.e., variable name).
    - In the case where supplier is a routine, indicate after the label name if it is deferred (*****), effective (**+**), or redefined (**++**).

Class Relations: Client-Supplier (2.1)

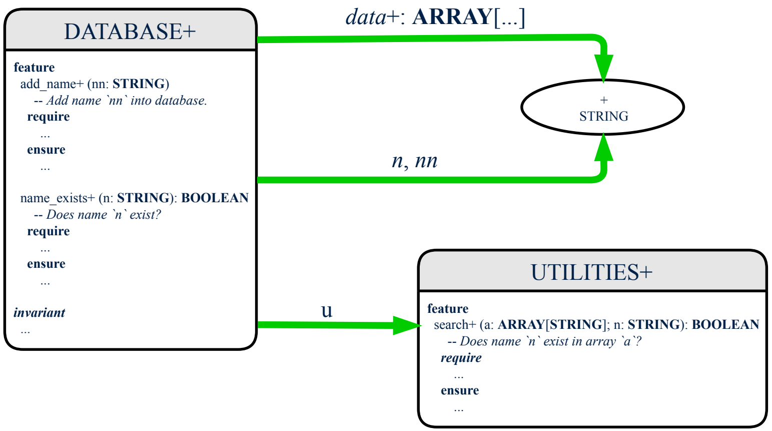
```
class DATABASE
feature {NONE} -- implementation
  data: ARRAY[STRING]
feature -- Commands
  add_name (nn: STRING)
      -- Add name 'nn' to database.
    require ... do ... ensure ... end

  name_exists (n: STRING): BOOLEAN
      -- Does name 'n' exist in database?
    require ...
    local
      u: UTILITIES
    do ... ensure ... end
invariant
  ...
end
```

```
class UTILITIES
feature -- Queries
  search (a: ARRAY[STRING]; n: STRING): BOOLEAN
      -- Does name 'n' exist in array 'a'?
    require ... do ... ensure ... end
end
```

- Query $\boxed{\texttt{data: ARRAY[STRING]}}$ indicates two suppliers: `STRING` and `ARRAY`.
- Parameters `nn` and `n` may have an arrow with label $\boxed{\text{nn, n}}$, pointing to the `STRING` class.
- Local variable `u` may have an arrow with label $\boxed{\text{u}}$, pointing to the `UTILITIES` class.

Class Relations: Client-Supplier (2.2.1)

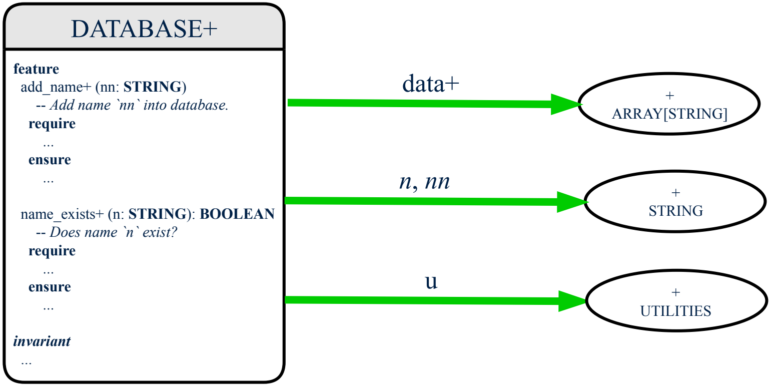
If `STRING` is to be emphasized, label is $\boxed{\texttt{data: ARRAY[...]}}$, where `...` denotes the supplier class `STRING` being pointed to.



Class Relations: Client-Supplier (2.2.2)

If `ARRAY` is to be emphasized, label is $\boxed{\texttt{data}}$.

The supplier's name should be complete: `ARRAY[STRING]`



Class Relations: Client-Supplier (3.1)

Known: The *deferred* class LIST has two *effective* descendants ARRAY_LIST and LINKED_LIST).

- DESIGN ONE:

```
class DATABASE_V1
feature {NONE} -- implementation
  imp: ARRAYED_LIST[PERSON]
... -- more features and contracts
end
```

- DESIGN TWO:

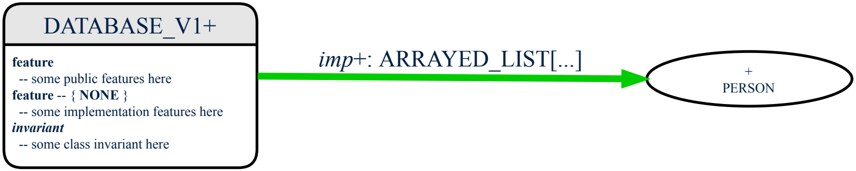
```
class DATABASE_V2
feature {NONE} -- implementation
  imp: LIST[PERSON]
... -- more features and contracts
end
```

Question: Which design is better? [DESIGN TWO]

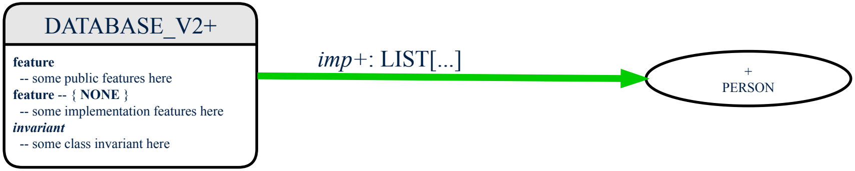
Rationale: Program to the ***interface***, not the ***implementation***.

Class Relations: Client-Supplier (3.2.1)

We may focus on the `PERSON` supplier class, which may not help judge which design is better.



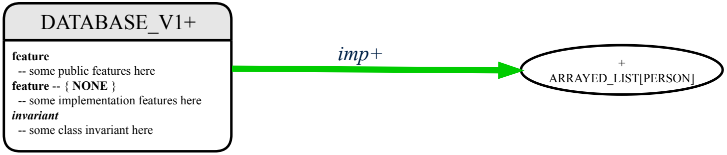
DATABASE_V1+
feature
-- some public features here
feature -- { NONE }
-- some implementation features here
invariant
-- some class invariant here
imp+: ARRAYED_LIST[...]
+
PERSON

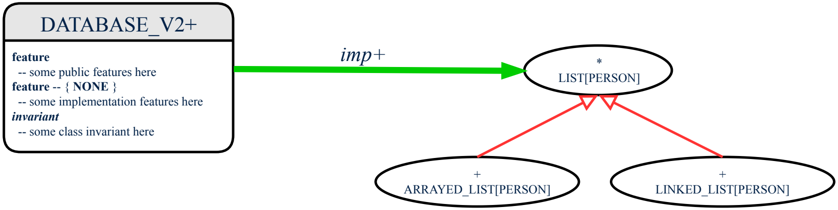


DATABASE_V2+
feature
-- some public features here
feature -- { NONE }
-- some implementation features here
invariant
-- some class invariant here
imp+: LIST[...]
+
PERSON

Class Relations: Client-Supplier (3.2.2)

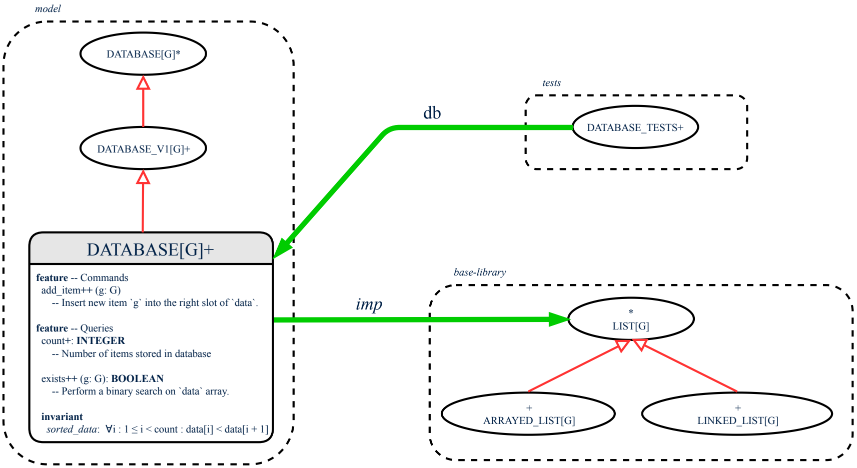
Alternatively, we may focus on the `LIST` supplier class, which in this case helps us judge which design is better.


DATABASE_V1+
feature
-- some public features here
feature -- { NONE }
-- some implementation features here
invariant
-- some class invariant here
imp+
+
ARRAYED_LIST[PERSON]



Clusters: Grouping Classes

Use *clusters* to group classes into logical units.



Beyond this lecture

- Your Lab0 introductory tutorial series contains the following classes:
  - `BIRTHDAY`
  - `BIRTHDAY_BOOK`
  - `TEST_BIRTHDAY`
  - `TEST_BIRTHDAY_BOOK`
  - `TEST_LIBRARY`
  - `BAD_BIRTHDAY_VIOLATING_DAY_SET`
  - `BIRTHDAY_BOOK_VIOLATING_NAME_ADDED_TO_END`

  Draw a ***design diagram*** showing the ***architectural relations*** among the above classes.

Index (1)

Index (2)

Index (3)