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

EECS3311 A & E: Software Design
Fall 2020

CHEN-WEI WANG

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]
  - features (queries and commands)

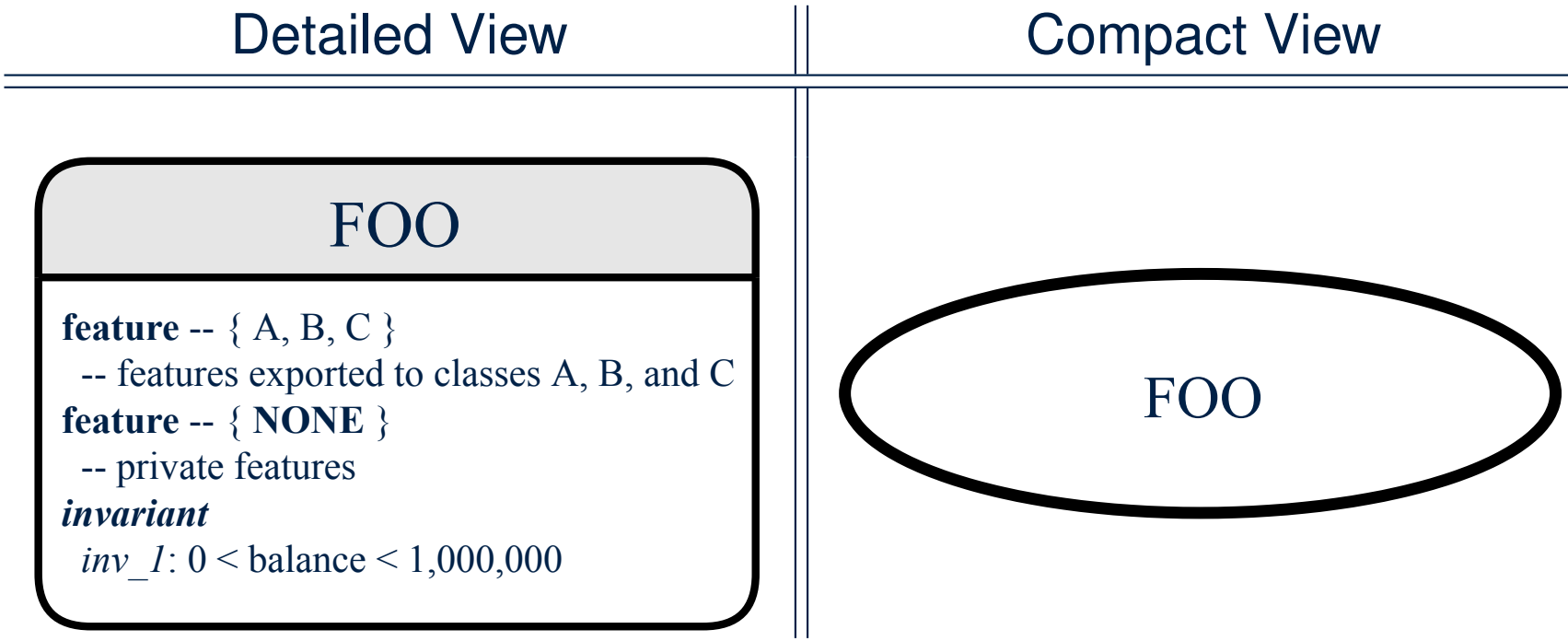
    [deferred vs. effective vs. redefined]
  - ***contracts***

    [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., ∀ instead of `across ... all ... end`).

Classes:
Detailed View vs. Compact View (1)

- 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
- 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)



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***:

HASH_TABLE[G, H]

HASH_TABLE[STRING, INTEGER]

HASH_TABLE[PERSON, INTEGER]

  - 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

DATABASE[STRING]

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

DATABASE[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

Deferred means ***unimplemented*** (≈ **abstract** in Java)

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
feature -- Queries
  search (g: G): BOOLEAN
      -- Perform a linear search on the database.
    deferred 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.
    deferred 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 * 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]+

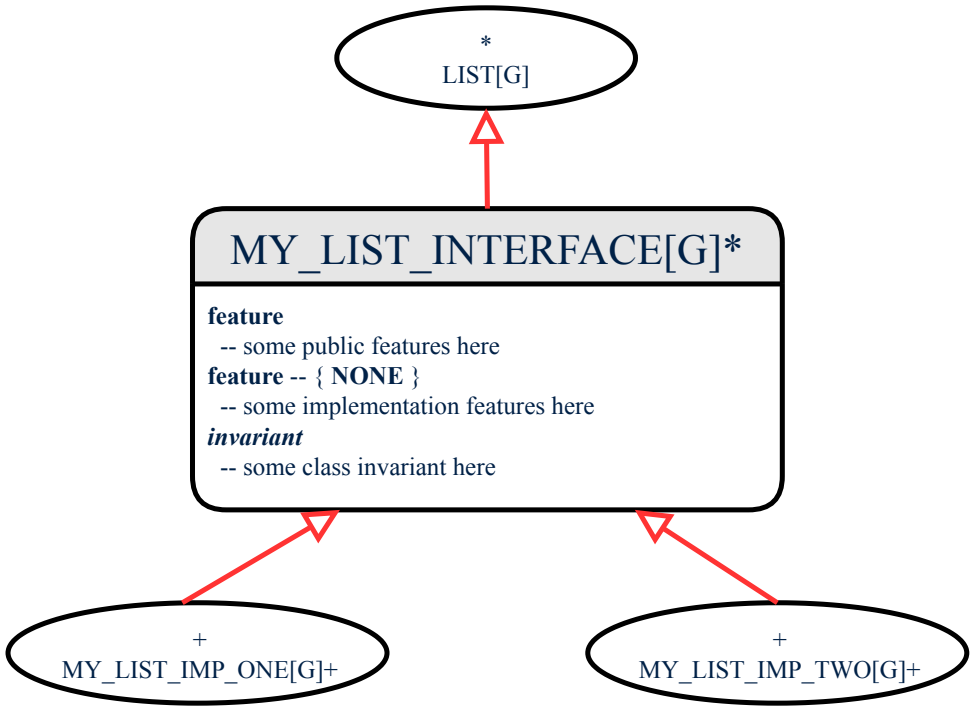
```
feature {NONE} -- Implementation
  data: ARRAY[G]

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)

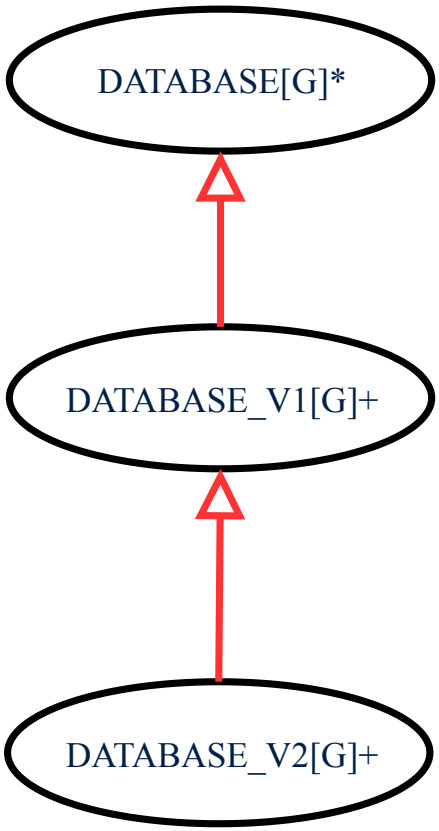
- An *inheritance hierarchy* is formed using ***red arrows***.
  - Arrow's ***origin*** indicates the ***child***/***descendant*** class.
  - Arrow's ***destination*** indicates the ***parent***/***ancestor*** class.
- You may choose to present each class in an inheritance hierarchy in either the detailed 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_V1[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 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 `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 label there should be a *label* indicating the **supplier name** (i.e., variable name).
  - In the case where supplier is an attribute, indicate after the label name if it is deferred (*), effective (+), or redefined (++).

Class Relations: Client-Supplier (2.1)

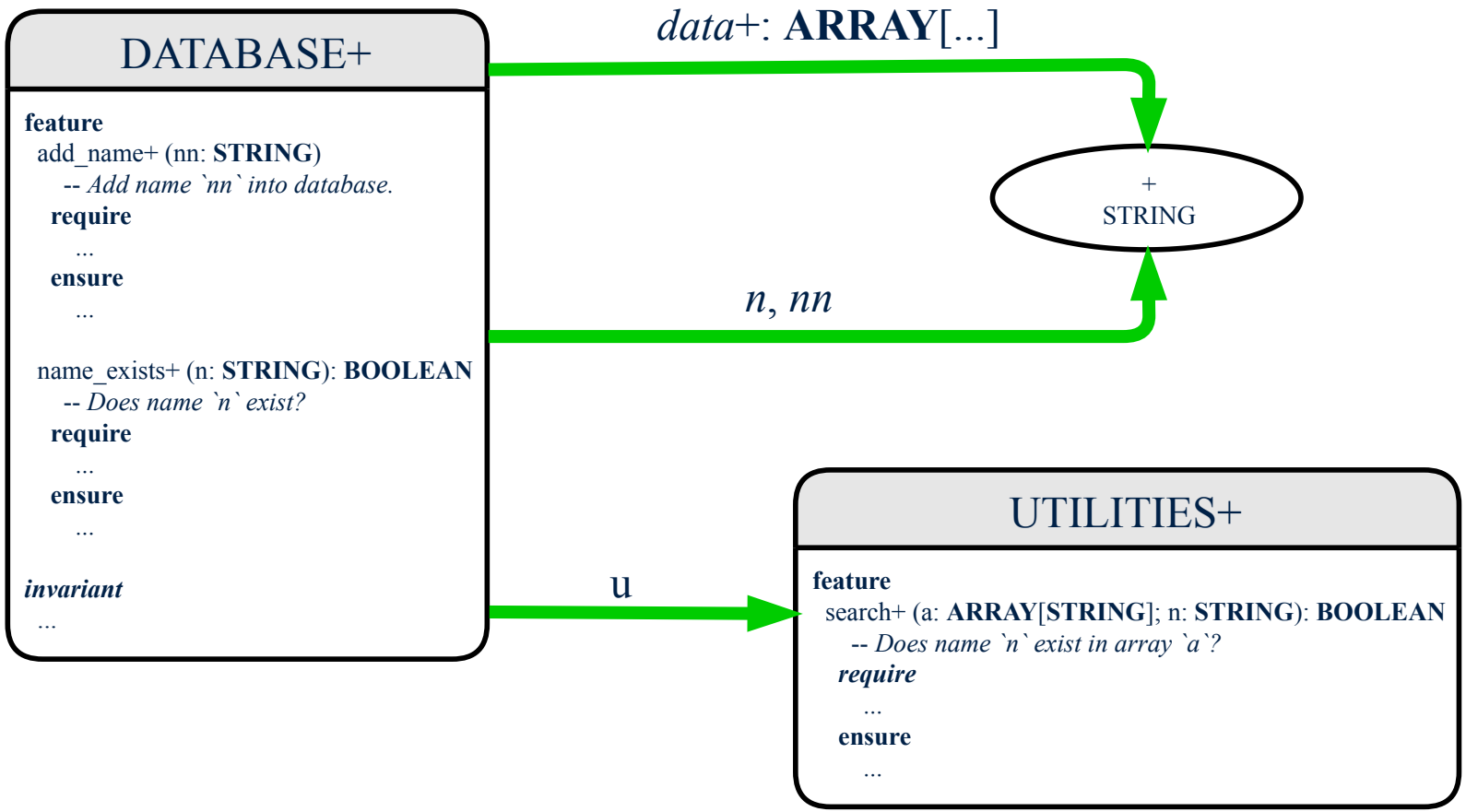
```
class DATABASE
feature {NONE} -- implementation
  data: ARRAY[STRING]
feature -- Commands
  add_name (nn: STRING)
      -- Add name 'nn' to database.
    require ... do ... ensure ... end

  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
```

- Attribute `data: ARRAY[STRING]` indicates two suppliers: `STRING` and `ARRAY`.
- Parameters `nn` and `n` may have an arrow with label `nn, n`, pointing to the `STRING` class.
- Local variable `u` may have an arrow with label `u`, pointing to the `UTILITIES` class.

Class Relations: Client-Supplier (2.2.1)

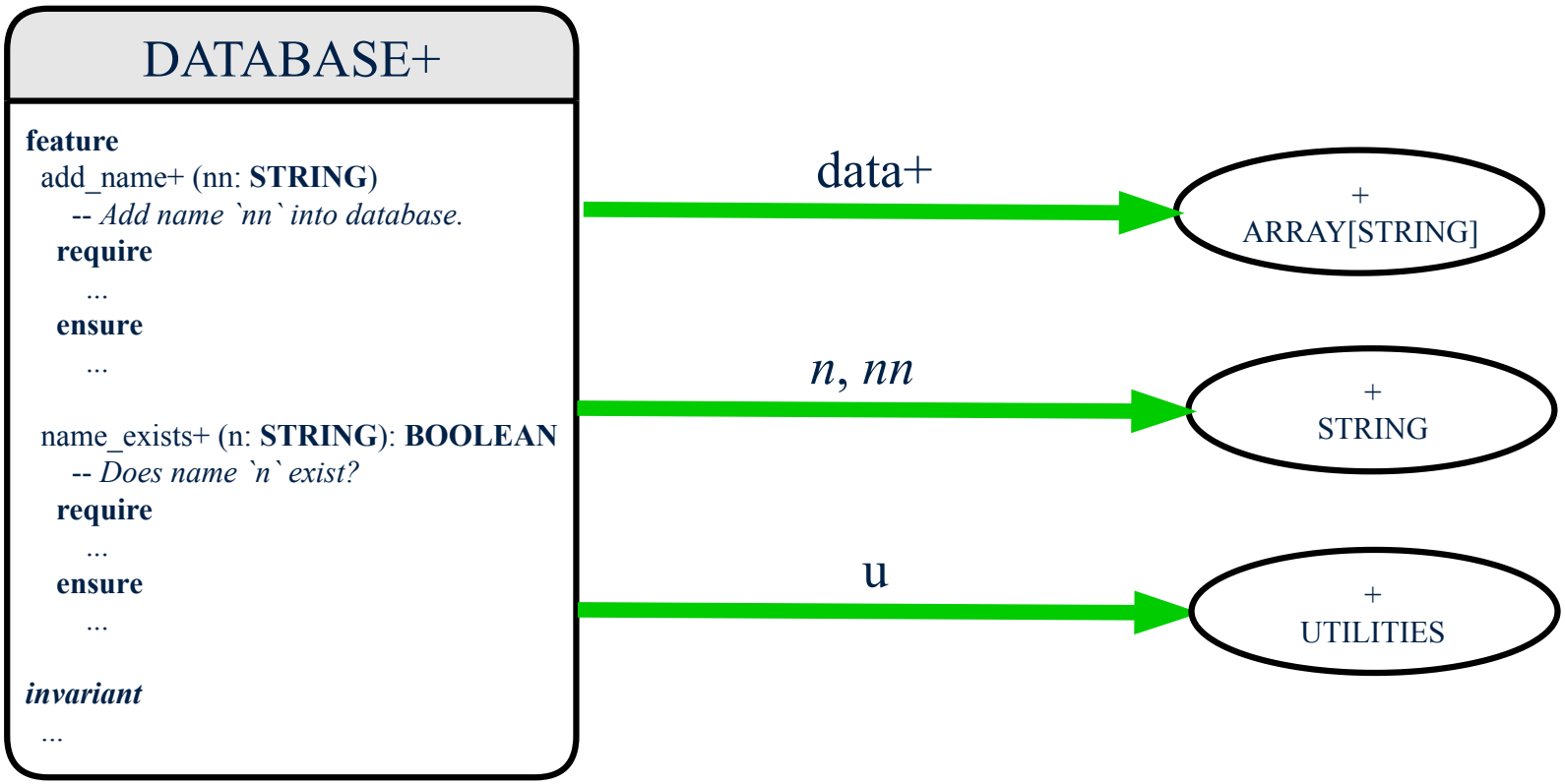
If `STRING` is to be emphasized, label is `data: ARRAY[...]`, where ... denotes the supplier class `STRING` being pointed to.



Class Relations: Client-Supplier (2.2.2)

If `ARRAY` is to be emphasized, label is `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:

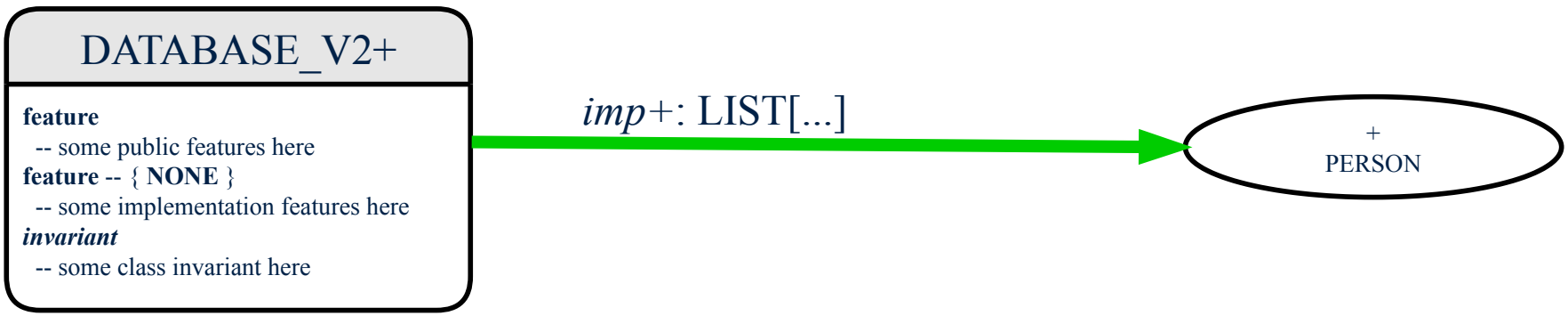
```
class DATABASE_V2
feature {NONE} -- implementation
  imp: LIST[PERSON]
... -- more features and contracts
end
```

Question: Which design is better? [DESIGN TWO]

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

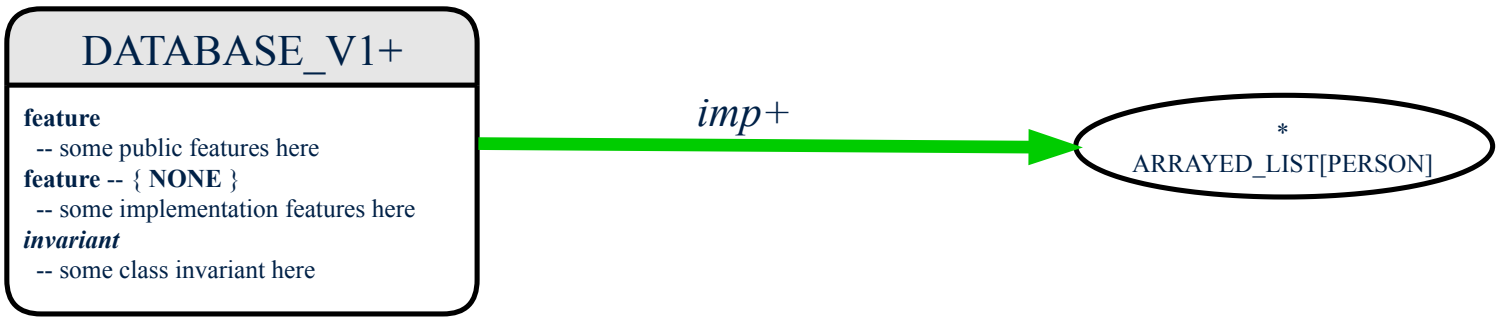
Class Relations: Client-Supplier (3.2.1)

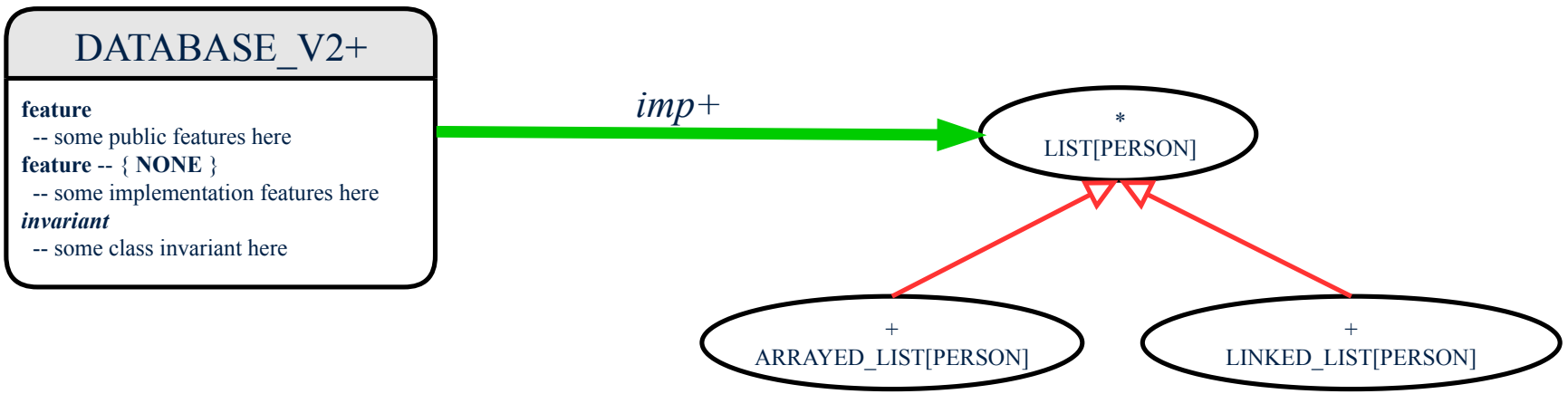
We may focus on the `PERSON` supplier class, which may not help judge which design is better.



Class Relations: Client-Supplier (3.2.2)

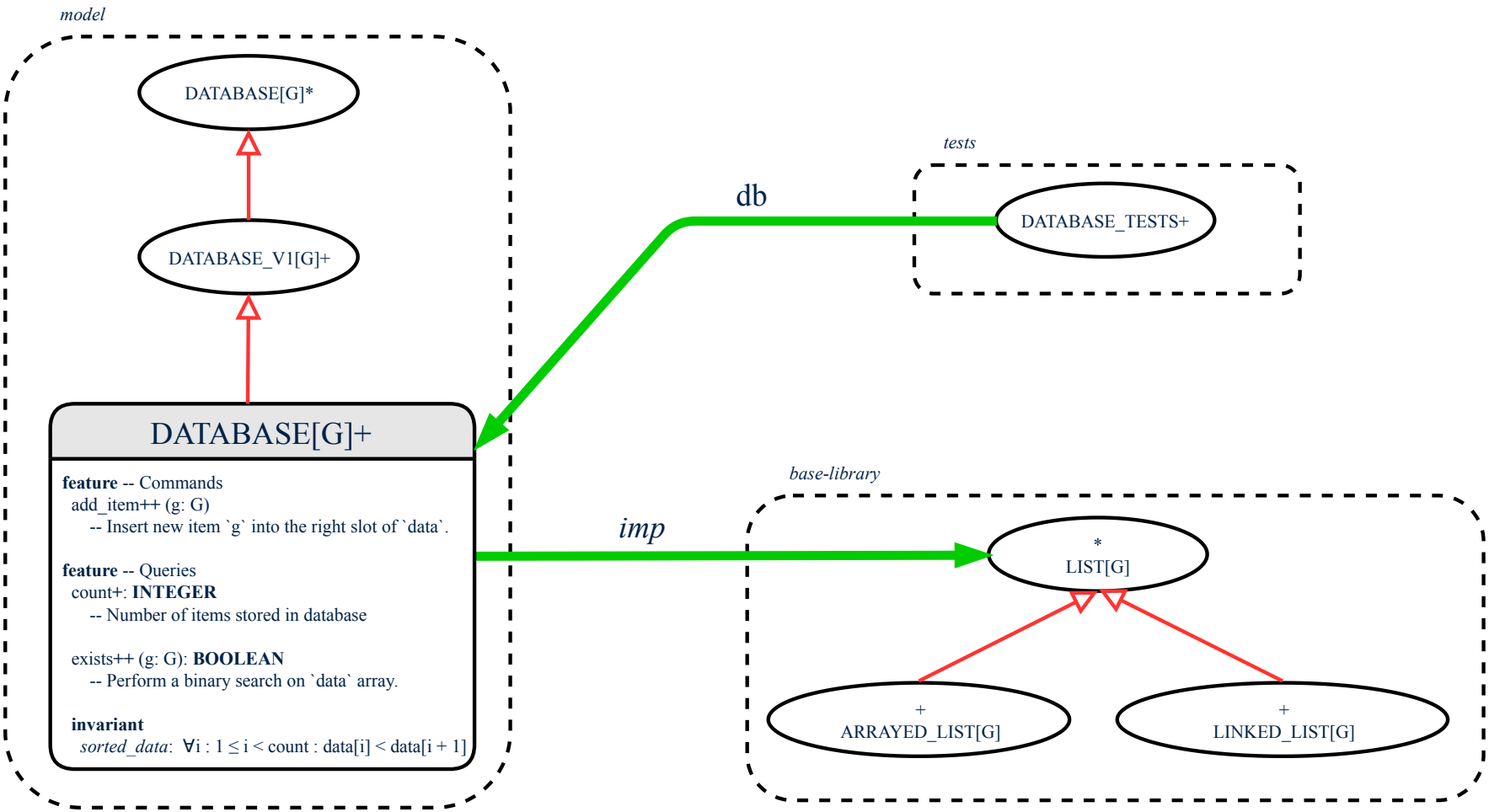
Alternatively, we may focus on the `LIST` supplier class, which in this case helps us judge which design is better.





Clusters: Grouping Classes

Use *clusters* to group classes into logical units.



Index (1)

Index (2)

Index (3)