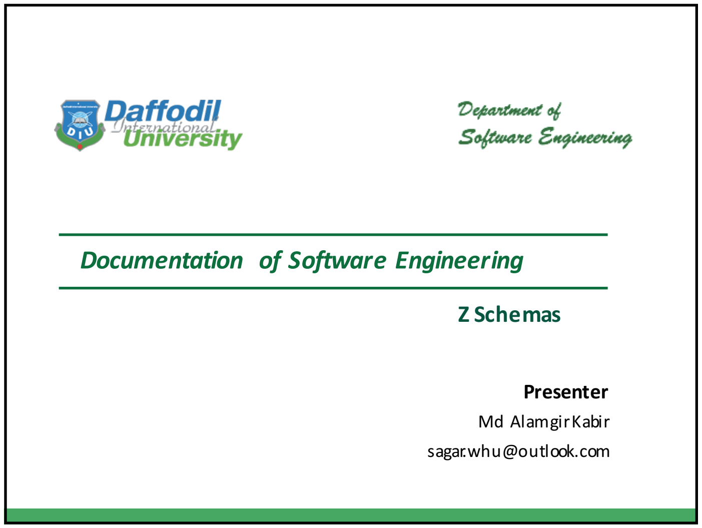

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Z Schemas

Presenter

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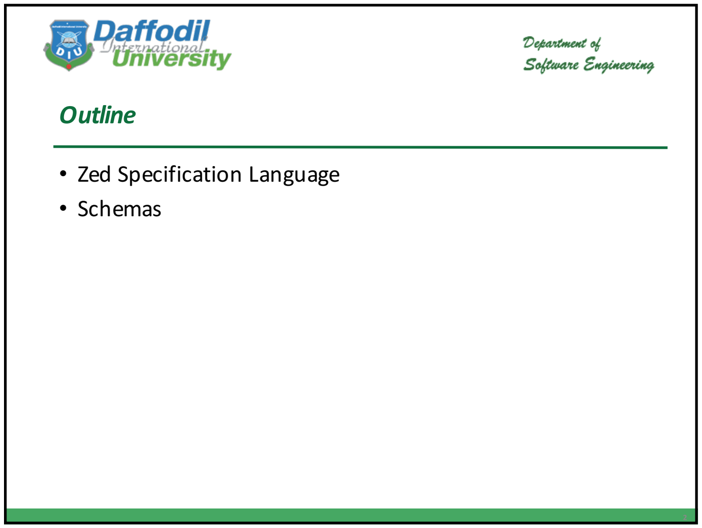

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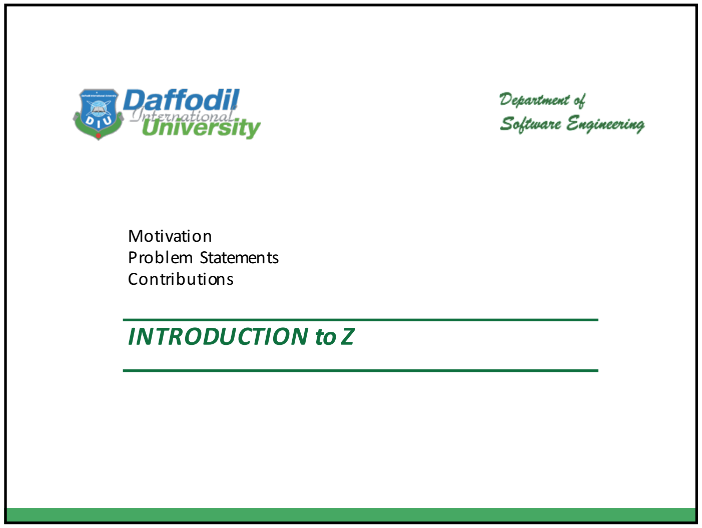
Outline

- Zed Specification Language
- Schemas



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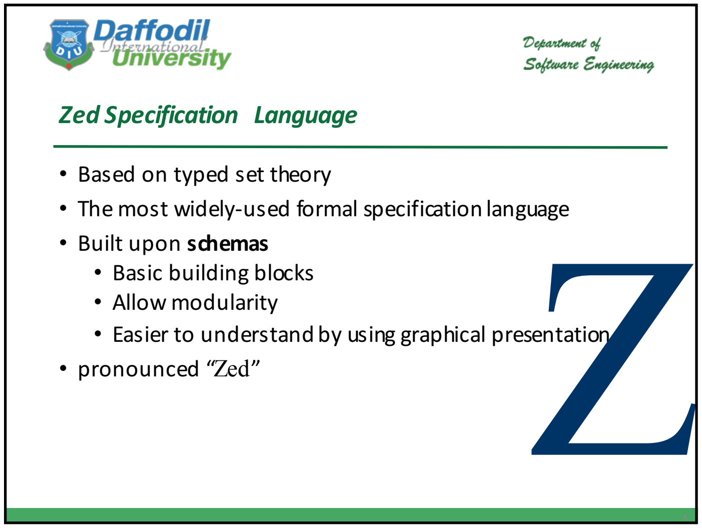
Motivation
Problem Statements
Contributions

INTRODUCTION to Z



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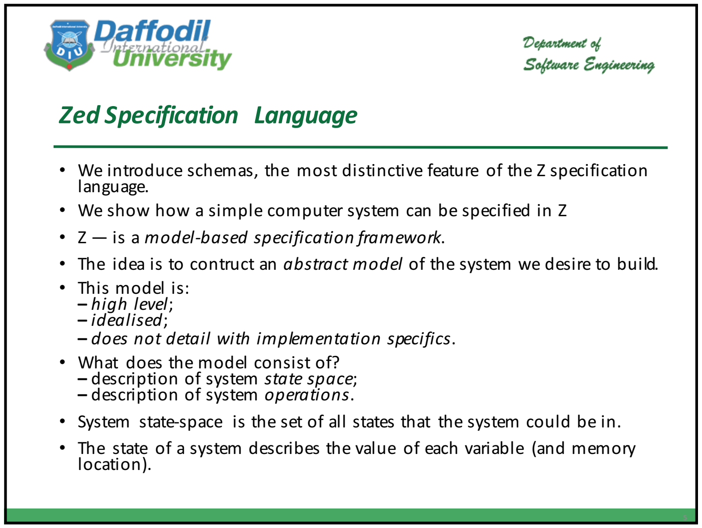
Zed Specification Language

- Based on typed set theory
- The most widely-used formal specification language
- Built upon **schemas**
  - Basic building blocks
  - Allow modularity
  - Easier to understand by using graphical presentation
- pronounced "Zed"

Z



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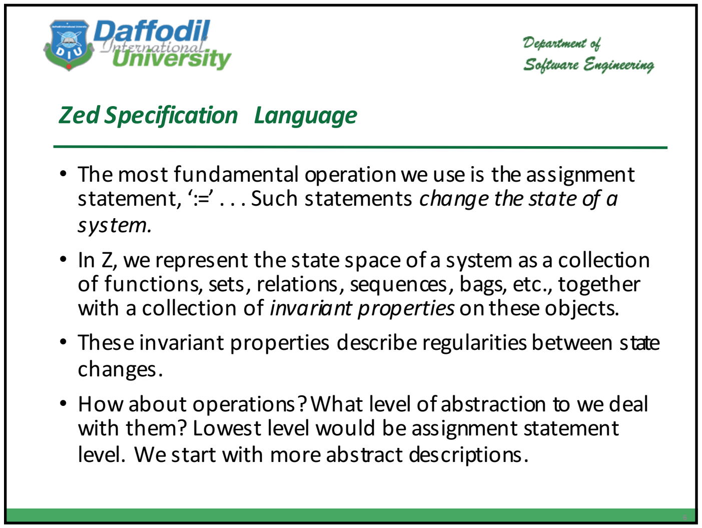
Zed Specification Language

- We introduce schemas, the most distinctive feature of the Z specification language.
- We show how a simple computer system can be specified in Z
- Z — is a *model-based specification framework*.
- The idea is to contruct an *abstract model* of the system we desire to build.
- This model is:
  - *high level*;
  - *idealised*;
  - *does not detail with implementation specifics*.
- What does the model consist of?
  - description of system *state space*;
  - description of system *operations*.
- System state-space is the set of all states that the system could be in.
- The state of a system describes the value of each variable (and memory location).



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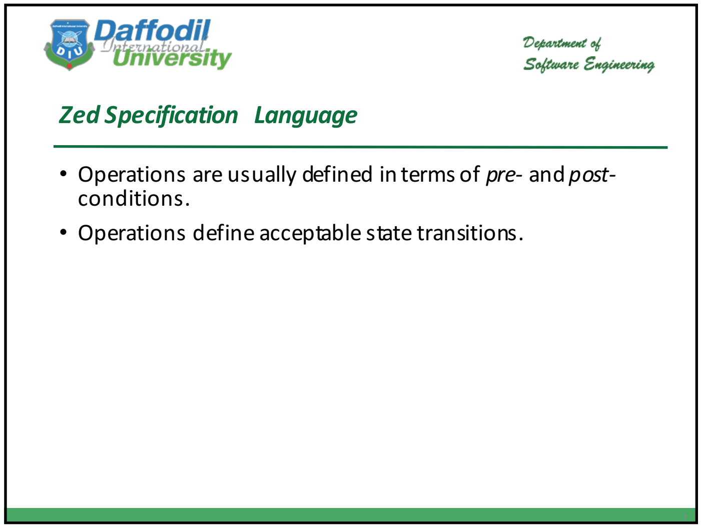
Zed Specification Language

- The most fundamental operation we use is the assignment statement, ':=' . . . Such statements *change the state of a system.*
- In Z, we represent the state space of a system as a collection of functions, sets, relations, sequences, bags, etc., together with a collection of *invariant properties* on these objects.
- These invariant properties describe regularities between state changes.
- How about operations? What level of abstraction to we deal with them? Lowest level would be assignment statement level. We start with more abstract descriptions.



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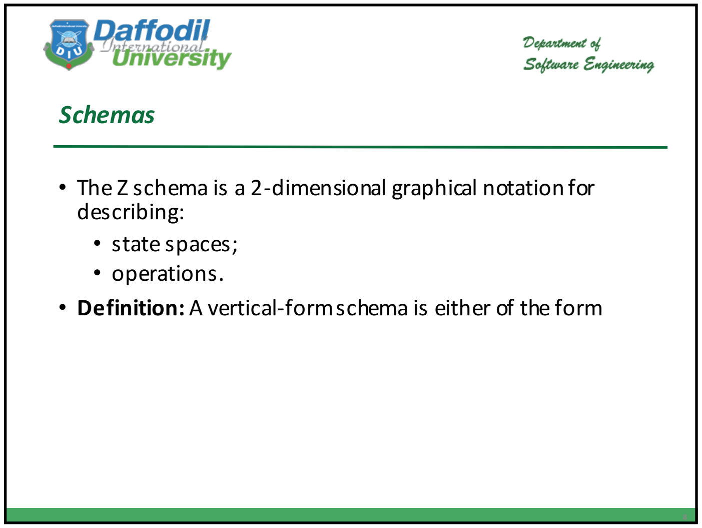
Zed Specification Language

- Operations are usually defined in terms of *pre*- and *post*-conditions.
- Operations define acceptable state transitions.



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Schemas

- The Z schema is a 2-dimensional graphical notation for describing:
  - state spaces;
  - operations.
- **Definition:** A vertical-form schema is either of the form

Z Schema

$SchemaName$

$Declarations$

$Predicate_1; \cdots ; Predicate_n$

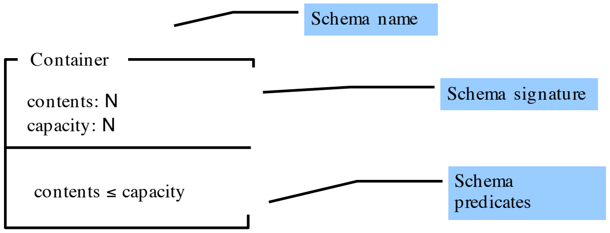
or of the form

$SchemaName$

$Declarations$

In the latter case, the predicate part is assumed to be 'true'.

Z Schema



Container

contents: N
capacity: N

contents ≤ capacity

Schema name

Schema signature

Schema predicates

Schema predicates are always true
Predicates can refer only to elements in the signature

- *SchemaName* will be associated with the schema proper, which is the contents of the box.
- The declarations part of the schema will contain:
  - a list of variable declarations; and
  - references to other schemas (this is called schema inclusion).
- Variable declarations have the usual form
  - $x_1,x_2,\ldots,x_n : T;$
- The predicate part of a schema contains a list of predicates, separated either by semi-colons or new lines.

State Space Schemas

- Here is an example state-space schema, representing part of a system that records details about the phone numbers of staff. (Assume that *NAME* is a set of names, and *PHONE* is a set of phone numbers.)

$PhoneBook$

$known : \mathbb{P}\, NAME$

$tel : NAME \nrightarrow PHONE$

$\mathrm{dom}\ tel = known$

State Space Schemas

- The declarations part of this schema introduces two variables: ***known*** and ***tel***.
- The value of ***known*** will be a subset of *NAME*, i.e., a set of names. [This variable will be used to represent all the names that we know about — those that we can give a phone number for.]
- The value of *tel* will be a partial function from *NAME* to *PHONE*, i.e., it will associate names with phone numbers.
- The domain of *tel* is always

equal to the set *known*.

```
PhoneBook ____________________
known : ℙ NAME
tel : NAME ⇸ PHONE
______________________________
dom tel = known
______________________________
```

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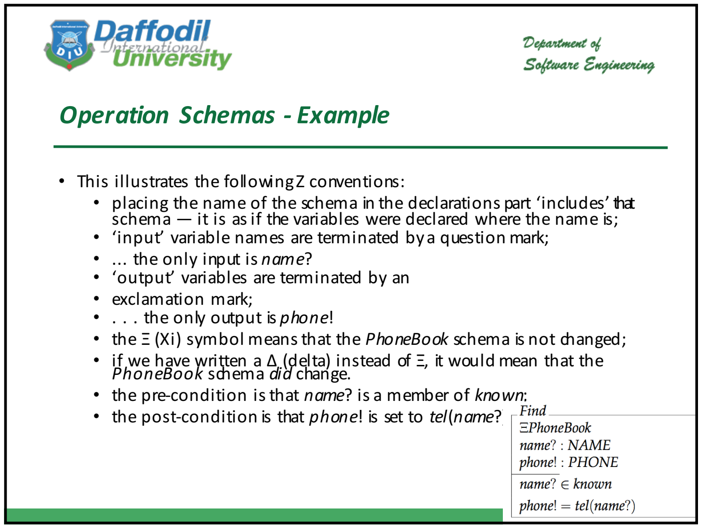
Operation Schemas

- In specifying a system operation, we must consider:
  - the objects that are *accessed* by the operation, and of these:
    - the objects that are *known to remain unchanged* by the operation (cf. value parameters);
    - the objects that *may be altered* by the operation (cf. variable parameter);
  - the *pre-conditions* of the operation, i.e., the things that must be true for the operation to succeed;
  - the *post-conditions* — the things that will be true after the operation, if the pre-condition was satisfied before the operation.

Operation Schemas - Example

- Return to the telephone book example, and consider the ‘lookup’ operation: we put a name in, and get a phone number out.
  - this operation accesses the *PhoneBook* schema;
  - it does not change it;
  - it takes a single ‘input’ — a name for which we want to find a phone number;
  - it produces a single output — a phone number.
  - it has the pre-condition that the name is known to the database.



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Operation Schemas - Example

- This illustrates the following Z conventions:
  - placing the name of the schema in the declarations part ‘includes’ that schema — it is as if the variables were declared where the name is;
  - ‘input’ variable names are terminated by a question mark;
  - ... the only input is *name*?
  - ‘output’ variables are terminated by an
  - exclamation mark;
  - . . . the only output is *phone*!
  - the Ξ (Xi) symbol means that the *PhoneBook* schema is not changed;
  - if we have written a Δ (delta) instead of Ξ, it would mean that the *PhoneBook* schema *did* change.
  - the pre-condition is that *name*? is a member of *known*;
  - the post-condition is that *phone*! is set to *tel*(*name*?

Find

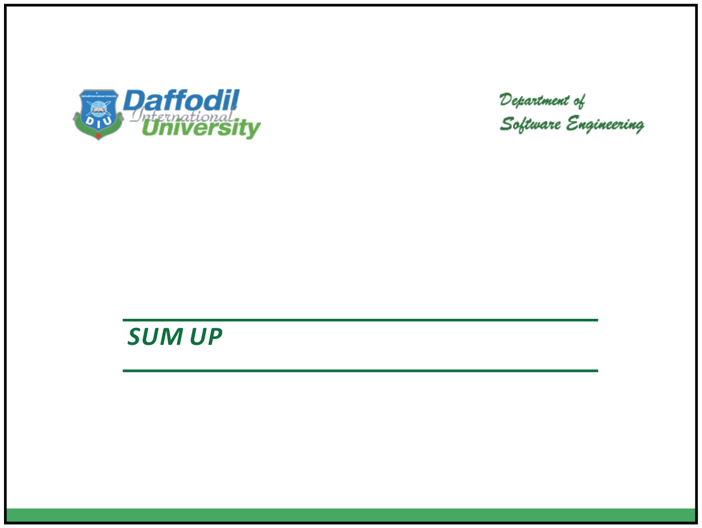
$\Xi PhoneBook$

$name? : NAME$

$phone! : PHONE$

$name? \in known$

$phone! = tel(name?)$



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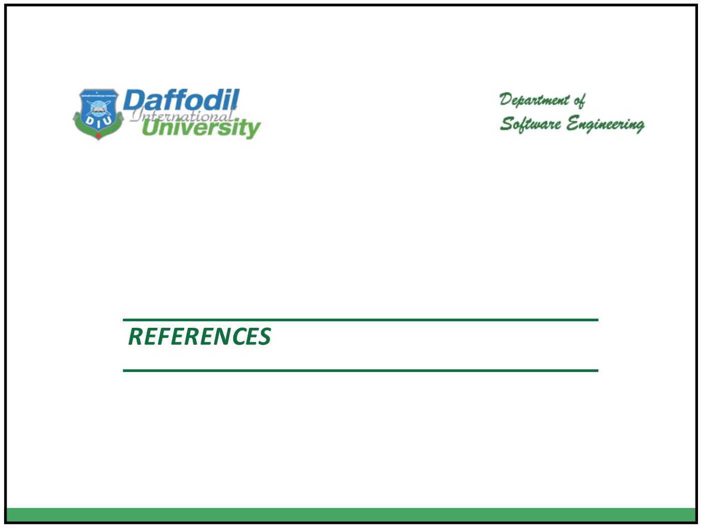
SUM UP



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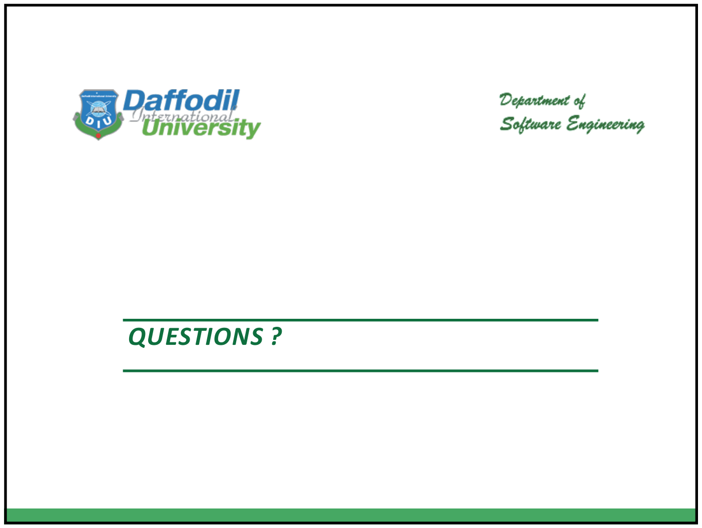

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QUESTIONS ?