Concordia University

Department of Computer Science and Software Engineering

SOEN 331 - S and U

Introduction to Formal Methods for Software Engineering

Assignment 2 - Solutions

The Object-Z specification language

Team 19 - Section U

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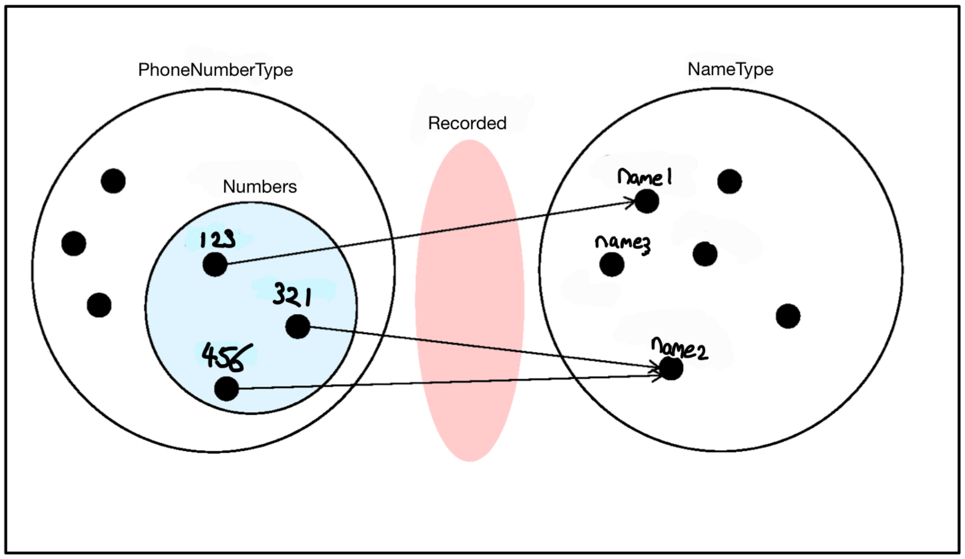
1 Contact management

1.1 State

1. This is our diagram for the state of the system:



2. The formal definition of *numbers* is as follows:

$$numbers \ : \ \mathbb{P}\ PhoneNumberType$$

3. The relation *recorded* must indeed be captured by a function. A function, by definition, enforces that each element of a source set (that is, the set in the domain) is mapped to exactly one element of a target set (a set of elements in the range). Part of the requirements for the system is that people may not share phone numbers. By making *recorded* a function, and setting the *numbers* set as a subset of the domain, the requirement of a phone number being associated to a single person is trivially met. If this is not done, an additional series of specifications must be defined such that this requirement is observed *at best*, and at worst, there is a severe risk of failing to meet the defined requirements. Thus, it is at least convenient, if not necessary that *recorded* is a function where *numbers* is a subset of the domain.

4. The domain of *recorded* is *numbers*, and its codomain is *NameType*.

5. The function *recorded* is a partial function, because partial functions, by definition, do not map all elements in the domain to an element in the co-domain. Specifically, *recorded* doesn't relate every element of PhoneNumberType to NameType.

6. The function *recorded* will not be either injective, surjective, or bijective. It cannot be injective because an injective function, by definition, is a function where one element in the domain is mapped to at most one element in the co-domain, but recorded allows for multiple phone numbers to be associated with one person, so multiple parts of the domain could be associated with an element of the co-domain. It cannot be surjective as a surjective function, by definition, is a function where each element in the co-domain has at least one element in the domain mapped to it. In *recorded*, there are elements contained in the co-domain of *recorded* that are not in the range of *recorded* therefore there exists elements in the codomain which are not mapped to by any element of the domain. It cannot be bijective because a bijective function is both injective and surjective and it has already been proven that this function is neither. Therefore, *recorded* must be a general function because every element in the domain is mapped to one element of the co-domain, but more than one element of the domain can be mapped to the same element of the co-domain.

7. The formal definition of *recorded* is as follows:

$$\mathit{recorded} : \mathit{PhoneNumberType} \nrightarrow \mathit{NameType}$$

1.2 Class Contacts

Contacts

$\upharpoonright (\mathit{MakeNewContact}, \mathit{AddNumber}, \mathit{SearchForNumber}, \mathit{DeleteNumber})$

$\mathit{numbers} : \mathbb{P}\,\mathit{PhoneNumberType}$
$\mathit{recorded} : \mathit{PhoneNumberType} \pfun \mathit{NameType}$

$\mathit{numbers} = \mathrm{dom}\ \mathit{recorded}$

Init

$\mathit{recorded} = \varnothing$

MakeNewContactOK

$\Delta(\mathit{recorded})$
$\mathit{number?} : \mathit{PhoneNumberType}$
$\mathit{name?} : \mathit{NameType}$

$\mathit{number?} \notin \mathit{numbers}$
$\mathit{name?} \notin \mathrm{ran}\ \mathit{recorded}$
$\mathit{recorded}' = \mathit{recorded} \cup \{\mathit{number?} \mapsto \mathit{name?}\}$

AddNumberOK

$\Delta(\mathit{recorded})$
$\mathit{number?} : \mathit{PhoneNumberType}$
$\mathit{name?} : \mathit{NameType}$

$\mathit{number?} \notin \mathit{numbers}$
$\mathit{name?} \in \mathrm{ran}\ \mathit{recorded}$
$\mathit{recorded}' = \mathit{recorded} \cup \{\mathit{number?} \mapsto \mathit{name?}\}$

SearchForNumberOK

$\Xi \mathit{Contacts}$
$\mathit{name?} : \mathit{NameType}$
$\mathit{numberset!} : \mathbb{P}\,\mathit{numbers}$

$\mathit{name?} \in \mathrm{ran}\ \mathit{recorded}$
$\mathit{numberset!} = \{n : \mathit{numbers} \mid \mathit{recorded}(n) = \mathit{name?}\}$

DeleteNumberOK

$\Delta(\mathit{recorded})$
$\mathit{number?} : \mathit{PhoneNumberType}$

$\mathit{number?} \in \mathit{numbers}$
$\mathit{recorded}' = \{\mathit{number?}\} \ndres \mathit{recorded}$

...

Contacts/cont.

...

NameUnknown

$name? : NameType$
$response! : Message$

$name? \notin \operatorname{ran} recorded$
$response! = 'Name\ unknown'$

NumberUnknown

$number? : PhoneNumberType$
$response! : Message$

$number? \notin \operatorname{dom} recorded$
$response! = 'Number\ unknown'$

NameExists

$name? : NameType$
$response! : Message$

$name? \in \operatorname{ran} recorded$
$response! = 'Name\ already\ exists'$

NumberExists

$number? : PhoneNumberType$
$response! : Message$

$number? \in \operatorname{dom} recorded$
$response! = 'Number\ already\ exists'$

Success

$response! : Message$

$response! = 'Success'$

$$MakeNewContact \mathrel{\widehat=} (MakeNewContactOK \land Success) \oplus (NameExists \lor NumberExists)$$

$$AddNumber \mathrel{\widehat=} (AddNumberOK \land Success) \oplus (NameUnknown \lor NumberExists)$$

$$SearchForNumber \mathrel{\widehat=} (SearchForNumberOK \land Success) \oplus (NameUnknown)$$

$$DeleteNumber \mathrel{\widehat=} (DeleteNumberOK \land Success) \oplus (NumberUnknown)$$

1.3 Class Contacts2

Contacts2

$\upharpoonright (\mathit{MakeNewContact}, \mathit{AddNumber}, \mathit{SearchForNumber}, \mathit{DeleteNumber},$
$\mathit{SearchForPerson})$

$\mathit{Contacts}$

SearchForPersonOK

$\Xi \mathit{Contacts2}$
$\mathit{number?} : \mathit{PhoneNumberType}$
$\mathit{name!} : \mathit{NameType}$

$\mathit{number?} \in \mathit{numbers}$
$\mathit{name!} = \mathit{recorded}(\mathit{number?})$

$\mathit{SearchForPerson} \mathrel{\widehat{=}} (\mathit{SearchForPersonOK} \land \mathit{Success}) \oplus (\mathit{NumberUnknown})$