◊
School Specification Extended
◊
Parent Section: "Z2 Toolkit"
◊
The set of all people is a given set for this specification.
Pupils are placed into classes and teachers are assigned to
teach classes.
◊
[PERSON,CLASS]

◊
The global variable ValidMark is a range of valid marks. The range is
zero to one hundred.
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$$\begin{array}{|l} \mathit{ValidMark} : \mathbb{P} \\ \hline \forall\ m : \quad \mid m \in \mathit{ValidMark} \bullet m \geq 0 \land m \leq 100 \end{array}$$

◊
State Schema
Belong is the set of all people who are affiliated to the school as a staff
member or as a student.
Staff is the set of all the teachers employed.
Pupil is the set of all students.
Prefect is the set of all prefects .
Head is the person who is in charge of the school.
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$$\begin{array}{|l} \mathit{School} \\ \hline \mathit{Belong}, \mathit{Staff}, \mathit{Pupil}, \mathit{Prefect}, \mathit{Head} : \mathbb{P}\ \mathit{PERSON} \\ \hline \mathit{Staff} \cap \mathit{Pupil} = \varnothing \\ \mathit{Staff} \cup \mathit{Pupil} = \mathit{Belong} \\ \mathit{Head} \subseteq \mathit{Staff} \\ \mathit{Prefect} \subseteq \mathit{Pupil} \\ \# \mathit{Head} \leq 1 \end{array}$$

◊
Nobody is both a Staff member and a Pupil.
The people who belong to the school are either Staff or Pupils.
The Head is a staff member.
Prefects are selected from the student body.
There is at most one head.
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EnrolledIn is a function that maps a person to his or her class.
Teacher maps a class to the teacher who is in charge of that class.
Marks is a mapping from a pupil to the set of marks they have been awarded.
The mark set is defined as a sequence which allows us to award the same
mark more than once and to distinguish between separate marks.
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$$\begin{array}{|l} \mathit{School2} \\ \hline \mathit{School} \\ \mathit{EnrolledIn} : \mathit{PERSON} \pfun \mathit{CLASS} \\ \mathit{Teacher} : \mathit{CLASS} \pfun \mathit{PERSON} \\ \mathit{Marks} : \mathit{PERSON} \pfun \mathit{seq}\ \mathit{ValidMark} \\ \hline \mathit{dom}\ \mathit{EnrolledIn} \subseteq \mathit{Pupil} \\ \mathit{ran}\ \mathit{Teacher} \subseteq \mathit{Staff} \\ \mathit{dom}\ \mathit{Marks} = \mathit{dom}\ \mathit{EnrolledIn} \end{array}$$

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All people enrolled in a class are pupils.
All teachers of classes are staff members.
All pupils have a mark record.
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Initialising
Initially there are no staff or pupils.
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InitSchool

$$Belong = \emptyset$$

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Initially no pupils are enrolled in classes, no teachers are assigned to classes, and no entries are in the mark record.
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InitSchool2

$$\Xi School$$

$$EnrolledIn = \emptyset$$
$$Teacher = \emptyset$$
$$Marks = \emptyset$$

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If Belong is the empty set then it follows from the state invariants expressed in the State schema that Staff, Pupil, Prefect and Head must also be empty sets.
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Operation Schemas

Staff Joining School
The input is a person.
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JoinStaffOK

$$\Delta School$$
$$s? : PERSON$$

$$s? \notin Belong$$
$$Belong' = Belong \cup \{s?\}$$
$$Staff' = Staff \cup \{s?\}$$
$$Pupil' = Pupil$$
$$Head' = Head$$
$$Prefect' = Prefect$$

◊
The input person does not currently belong to the school.
The input person is added to the set of people who belong to the school. Note this predicate is redundant as (Staff U Pupil = Belong) but it is included for clarity.
The input person is added to the set of staff.
The set of pupils is unchanged.
The Head is unchanged.
The set of Prefects is unchanged.
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Pupils Joining School
The input is a person.
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JoinPupilOK
ΔSchool
p? : PERSON
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p? ∉ Belong
Belong′ = Belong ∪ {p?}
Pupil′ = Pupil ∪ {p?}
Staff′ = Staff
Head′ = Head
Prefect′ = Prefect

◊
The input person does not currently belong to the school.
The input person is added to the set of people who belong
to the school. Note this predicate is redundant as
(Staff U Pupil = Belong) but it is included for clarity.
The input person is added to the set of pupils.
The set of staff is unchanged.
The Head is unchanged.
The set of Prefects is unchanged.
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Staff Leaving School
The input is a person.
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LeaveStaffOK
ΔSchool
s? : PERSON
---
s? ∈ Staff
Belong′ = Belong \ {s?}
Staff′ = Staff \ {s?}
Pupil′ = Pupil
Head′ = Head
Prefect′ = Prefect

◊
The input person is a staff member.
The input person is removed from the set of people who belong to the school.
The input person is removed from the set of staff.
The set of pupils is unchanged.
The Head is unchanged.
The set of Prefects is unchanged.
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Pupil Leaving School
The input is a person.
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┌─LeavePupilOK──────────────────────────────────────┐
│ ΔSchool   │
│ p? : PERSON   │
├───────────────────────   │
│ p? ∈ Pupil   │
│ Belong′ = Belong \ {p?}   │
│ Pupil′ = Pupil \ {p?}   │
│ Prefect′ = Prefect \ {p?}   │
│ Staff′ = Staff   │
│ Head′ = Head   │
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The input person currently is a pupil.
The input person is removed from the set of people who belong to the school.
The input person is removed from the set of pupils.
As the pupil may be a prefect the set of prefects is updated.
The set of staff is unchanged.
The Head is unchanged.

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Appoint Head
The input is a person.

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┌─AppointHeadOK─────────────────────────────────────┐
│ ΔSchool   │
│ s? : PERSON   │
├───────────────────────   │
│ s? ∈ Staff   │
│ Head = ∅   │
│ Head′ = {s?}   │
│ Belong′ = Belong   │
│ Staff′ = Staff   │
│ Pupil′ = Pupil   │
│ Prefect′ = Prefect   │
└───┘

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The input person currently is a staff member.
There is no current head.
The input person is designated as head.
The set of staff is unchanged.
The set of pupils is unchanged.
The set of Prefects is unchanged.

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Dismiss Head
The input is a person.

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┌─DismissHeadOK─────────────────────────────────────┐
│ ΔSchool   │
│ s? : PERSON   │
├───────────────────────   │
│ Head = {s?}   │
│ Head′ = ∅   │
│ Belong′ = Belong   │
│ Staff′ = Staff   │
│ Pupil′ = Pupil   │
│ Prefect′ = Prefect   │
└───┘

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There is no head after this operation.
The set of staff is unchanged.
The set of pupils is unchanged.
The set of Prefects is unchanged.
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Appoint Prefects
The input is a set of people.
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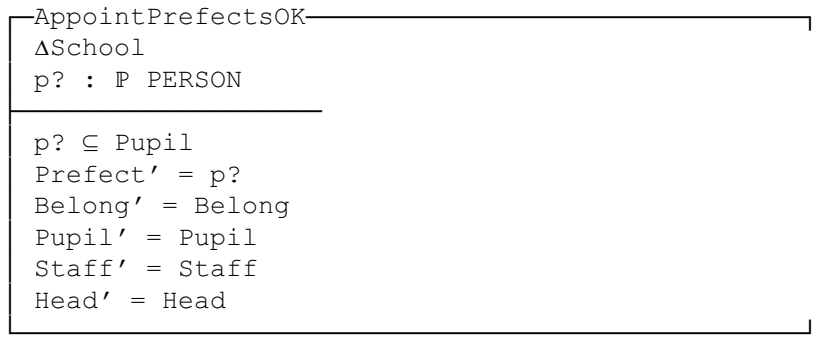

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The set of people are a subset of Pupil (and hence a subset of Belong as well)
The set of people are designated as Prefects.
The set of pupils is unchanged.
The set of staff is unchanged.
The Head is unchanged.
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Dismiss Prefects
There are no designated prefects after this operation.
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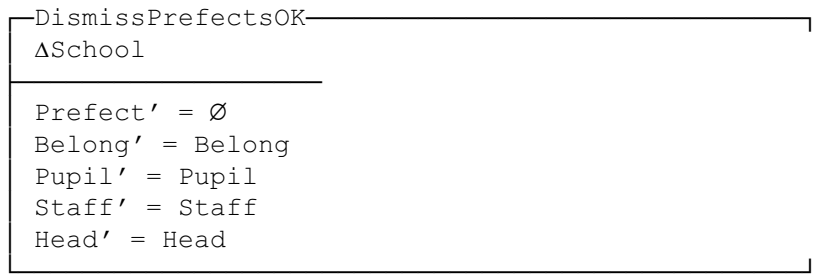

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The set of pupils is unchanged.
The set of staff is unchanged.
The Head is unchanged.
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Additional operations.

Pupils Joining Classes
The input p? is an enrolling pupil.
The input c? is the class that the pupil will join.
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EnrolPupil

ΔSchool2
ΞSchool
p? : PERSON
c? : CLASS

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p? $\in$ Pupil
p? $\notin$ dom EnrolledIn
EnrolledIn′ = EnrolledIn $\cup$ {p? $\mapsto$ c?}
Marks′ = Marks $\cup$ {p? $\mapsto$ $\langle\rangle$}
Teacher′ = Teacher

$\Diamond$
The enrolling pupil must be an existing pupil.
The pupil must not be currently enrolled in a class.
The pupil is added to the set of pupils in the class.
The pupil is added to the markbook with no marks.
The allocation of teachers to classes is unchanged.
$\Diamond$
$\Diamond$
Assigning Teachers to Classes
The input p? is a teacher.
The input c? is the class that the teacher will teach.
$\Diamond$

AssignTeacher

ΔSchool2
ΞSchool
p? : PERSON
c? : CLASS

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p? $\in$ Staff
p? $\notin$ ran Teacher
Teacher′ = Teacher $\cup$ {c? $\mapsto$ p?}
Marks′ = Marks
EnrolledIn′ = EnrolledIn

$\Diamond$
The input teacher must be a staff member.
The teacher must not already be allocated to a class.
The class/teacher mapping is added to the set of class/teacher mappings.
The markbook is unaffected.
Pupil enrolments are unaffected.
$\Diamond$
$\Diamond$
Awarding Marks to Pupils
The input p? is the pupil having a mark awarded.
The input m? is the mark awarded.
$\Diamond$

AwardMarks

ΔSchool2
ΞSchool
p? : PERSON
m? :

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p? $\in$ dom EnrolledIn
Marks′ = Marks $\oplus$ {p? $\mapsto$ Marks p? $\frown$ $\langle$m?$\rangle$}
Teacher′ = Teacher
EnrolledIn′ = EnrolledIn

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The pupil must belong to a class.
The new mark is added to the markbook.
The allocation of teachers to classes is unchanged.
Pupil enrolments are unaffected.
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Removing a Teacher from a Class
The input p? is the teacher who is being removed.
The input c? is the class the teacher is being removed from.
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RemoveTeacher

$\Delta School2$
$\Xi School$
$p? : PERSON$
$c? : CLASS$

$c? \mapsto p? \in Teacher$
$Teacher' = Teacher \rhd \{p?\}$
$EnrolledIn' = EnrolledIn$
$Marks' = Marks$

◊
The teacher must be currently allocated to a Class.
The teacher is deallocated from the Class.
Pupil enrolments are unaffected.
The mark record is unchanged.
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Removing a Pupil from a Class
The input p? is the pupil who is leaving a class and c? is the
class they are leaving from.
◊

RemovePupil

$\Delta School2$
$\Xi School$
$p? : PERSON$
$c? : CLASS$

$p? \mapsto c? \in EnrolledIn$
$EnrolledIn' = \{p?\} \lhd EnrolledIn$
$Teacher' = Teacher$
$Marks' = Marks$

◊
The pupil must currently belong to a class.
The pupil is removed from this class.
The allocation of teachers to classes is unchanged.
The markbook is unchanged.
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