

## Several proposals for a solution to EX98.1

**scheme**

Hospital =

**class**

**type**

WardId,

PersonNr,

Record,

Patient = PersonNr,

Nurse = PersonNr,

Doctor = PersonNr

**type**

Hospital = { | h : Hospital' • is\_wff(h) | },

Hospital' ::

doctors : Doctor  $\xrightarrow{m}$  WardId

nurses : Nurse  $\xrightarrow{m}$  WardId

patients : Patient  $\xrightarrow{m}$  WardId  $\times$  Record

wards : WardId-set

**value**

is\_wff : Hospital'  $\rightarrow$  **Bool**

is\_wff(h)  $\equiv$

**let** mk\_Hospital'(dm, nm, pm, ws) = h **in**

**dom** dm  $\cap$  **dom** nm = { }  $\wedge$

**dom** dm  $\cap$  **dom** pm = { }  $\wedge$

**dom** pm  $\cap$  **dom** nm = { }  $\wedge$

**rng** dm  $\cup$  **rng** nm  $\cup$  { w | w : WardId •  $\exists r : \text{Record} \bullet (w, r) \in \text{rng pm}$  }  $\subseteq$   
ws

**end,**

is\_in : PersonNr  $\times$  Hospital  $\rightarrow$  **Bool**

is\_in(pid, h)  $\equiv$  pid  $\in$  **dom** patients(h),

discharge : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  Hospital

discharge(pid, h)  $\equiv$

mk\_Hospital'(doctors(h), nurses(h), patients(h) \ {pid}, wards(h))

**pre** is\_in(pid, h),

doctors : WardId  $\times$  Hospital  $\xrightarrow{\sim}$  Doctor-set

doctors(w, h)  $\equiv$

{ d | d : Doctor • d  $\in$  **dom** doctors(h)  $\wedge$  doctors(h)(d) = w }

**pre** w  $\in$  wards(h)

**end**

**scheme**

Hospital2 =

**class**

**type**

WardId,  
 PersonNr,  
 Record,  
 Patient = PersonNr,  
 Nurse = PersonNr,  
 Doctor = PersonNr

**type**

Hospital = { | h : Hospital' • is\_wff(h) | },  
 Hospital' ::  
   wards : WardId  $\multimap$  Doctor-set  $\times$  Nurse-set  
   patients : Patient  $\multimap$  WardId  $\times$  Record

**value**

is\_wff : Hospital'  $\rightarrow$  **Bool**  
 is\_wff(h)  $\equiv$   
   **let** mk\_Hospital'(ws, pat) = h **in**  
   (  
      $\forall w1, w2 : \text{WardId} \bullet$   
      $\{w1, w2\} \subseteq \text{dom } ws \wedge w1 \neq w2 \Rightarrow$   
      $\text{employees}(ws(w1)) \cap \text{employees}(ws(w2)) = \{\}$   
   )  $\wedge$   
   (  
      $\forall w : \text{WardId} \bullet$   
      $w \in \text{dom } ws \Rightarrow$   
     **let** (ds, ss) = ws(w) **in**  $ds \cap ss = \{\} \wedge (ds \cup ss) \cap \text{dom } pat = \{\}$  **end**  
   )  
**end,**

employees : Doctor-set  $\times$  Nurse-set  $\rightarrow$  PersonNr-set  
 employees(ds, ss)  $\equiv ds \cup ss,$

is\_in : PersonNr  $\times$  Hospital  $\rightarrow$  **Bool**  
 is\_in(pid, h)  $\equiv pid \in \text{dom } \text{patients}(h),$

discharge : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  Hospital  
 discharge(pid, h)  $\equiv \text{mk\_Hospital}'(\text{wards}(h), \text{patients}(h) \setminus \{pid\})$  **pre** is\_in(pid, h),

doctors : WardId  $\times$  Hospital  $\xrightarrow{\sim}$  Doctor-set  
 doctors(a, h)  $\equiv$  **let** (ds, ss) = wards(h)(a) **in** ds **end pre** a  $\in \text{dom } \text{wards}(h)$

**end**

**scheme**

Hospital3 =

**class**

**type**

WardId,  
 PersonNr,  
 Record,  
 Patient = PersonNr,  
 Nurse = PersonNr,  
 Doctor = PersonNr

**type**

Hospital = { | h : Hospital' • is\_wff(h) | },  
 Hospital' = WardId  $\overrightarrow{m}$  WardInfo,  
 WardInfo :: docs : Doctor-**set** nurses : Nurse-**set** patients : Patient  $\overrightarrow{m}$  Record

**value**

is\_wff : Hospital'  $\rightarrow$  **Bool**

is\_wff(h)  $\equiv$

(  
 $\forall w1, w2 : \text{WardId} \bullet$   
 $\{w1, w2\} \subseteq \mathbf{dom} h \wedge w1 \neq w2 \Rightarrow$   
**let**  
 $\text{mk\_WardInfo}(ds1, ns1, ps1) = h(w1), \text{mk\_WardInfo}(ds2, ns2, ps2) = h(w2)$   
**in**  
 $(ds1 \cup ns1 \cup \mathbf{dom} ps1) \cap (ds2 \cup ns2 \cup \mathbf{dom} ps2) = \{\}$   
**end**  
 )  $\wedge$   
 (  
 $\forall w : \text{WardId} \bullet$   
 $w \in \mathbf{dom} h \Rightarrow$   
**let**  $\text{mk\_WardInfo}(ds, ns, ps) = h(w)$  **in**  
 $ds \cap ns = \{\} \wedge ds \cap \mathbf{dom} ps = \{\} \wedge ns \cap \mathbf{dom} ps = \{\}$   
**end**  
 ),

is\_in : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  **Bool**

is\_in(pid, h)  $\equiv (\exists w : \text{WardId} \bullet w \in \mathbf{dom} h \wedge \text{pid} \in \mathbf{dom} \text{patients}(h(w)))$ ,

discharge : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  Hospital

discharge(pid, h)  $\equiv$

[  
 $w \mapsto$   
**let**  $\text{mk\_WardInfo}(ls, ss, ps) = h(w)$  **in**  $\text{mk\_WardInfo}(ls, ss, ps \setminus \{\text{pid}\})$  **end**  
 |  
 $w : \text{WardId} \bullet w \in \mathbf{dom} h$   
 ]

```
    pre is_in(pid, h),  
  
    doctors : WardId  $\times$  Hospital  $\xrightarrow{\sim}$  Doctor-set  
    doctors(w, h)  $\equiv$  docs(h(w)) pre w  $\in$  dom h  
end
```

**scheme**

Hospital4 =

**class**

**type**

WardId,  
PersonNr,  
Record

**type**

Hospital = PersonNr  $\xrightarrow{m}$  PersonInfo,  
PersonInfo :: ward : WardId kind : Kind,  
Kind == doctor | nurse | patient(r : Record)

**value**

is\_in : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  **Bool**

is\_in(pid, h)  $\equiv$   
pid  $\in$  **dom** h  $\wedge$   
**case** kind(h(pid)) **of**  
  patient( $\_$ )  $\rightarrow$  **true**,  
   $\_$   $\rightarrow$  **false**  
**end**,

discharge : PersonNr  $\times$  Hospital  $\xrightarrow{\sim}$  Hospital

discharge(pid, h)  $\equiv$   
h  $\setminus$  {pid}  
**pre** is\_in(pid, h),

doctors : WardId  $\times$  Hospital  $\xrightarrow{\sim}$  PersonNr-**set**

doctors(w, h)  $\equiv$   
{ pid | pid : PersonNr  $\bullet$  pid  $\in$  **dom** h  $\wedge$  ward(h(pid)) = w  $\wedge$  kind(h(pid)) = doctor }  
**pre** w  $\in$  { w' | w' : WardId  $\bullet$  ( $\exists$  k : Kind  $\bullet$  mk\_PersonInfo(w', k)  $\in$  **rng** h) }

**end**

This solution has the disadvantage that it can't model an empty ward.