```
CONTEXT
   context0
SETS
   pid_t       //   set of applications
END
```

```
CONTEXT
   context1
EXTENDS
   context0
SETS
   app_knobs_disc_t       //   set of application discrete knobs
   app_knobs_cont_t       //   set of application continuous knobs
   app_mons_disc_t       //   set of application discrete monitors
   app_mons_cont_t       //   set of application continuous monitors
END
```

```
CONTEXT
   context2
EXTENDS
   context1
CONSTANTS
   MIN_INFINITY
   MAX_INFINITY
AXIOMS
   axm1   :   MIN_INFINITY ∈ ℤ
   axm2   :   MAX_INFINITY ∈ ℤ
END
```

```
MACHINE
   machine0
SEES
   context0
EVENTS
   INITIALISATION   ≙
   STATUS
    ordinary
   BEGIN
    skip
   END

   PRIME_API_APP_RTM   ≙
   STATUS
    ordinary
   ANY
    proc_id
   WHERE
    grd1   :   proc_id ∈ pid_t
   THEN
    skip
   END

   PRIME_API_DEV_RTM   ≙
   STATUS
    ordinary
   BEGIN
    skip
   END

END
```

```
MACHINE
   machine1       //   refining PRIME_API_APP_RTM
REFINES
   machine0
SEES
   context1
VARIABLES
   app_sockets       //   set of registered applications
   app_knobs_disc       //   set of registered application discrete knobs
   app_knobs_cont       //   set of registered application continuous knobs
   app_mons_disc       //   set of registered application discrete monitors
   app_mons_cont       //   set of registered application continuous monitors
INVARIANTS
   inv1   :   app_sockets ⊆ pid_t
   inv2   :   app_knobs_disc ∈ app_sockets ↔ app_knobs_disc_t
   inv3   :   app_knobs_cont ∈ app_sockets ↔ app_knobs_cont_t
   inv4   :   app_mons_disc ∈ app_sockets ↔ app_mons_disc_t
   inv5   :   app_mons_cont ∈ app_sockets ↔ app_mons_cont_t
EVENTS
   INITIALISATION   ≙
    extended
   STATUS
    ordinary
   BEGIN
    act1   :   app_sockets ≔ ∅
    act2   :   app_knobs_disc ≔ ∅
    act3   :   app_knobs_cont ≔ ∅
    act4   :   app_mons_disc ≔ ∅
    act5   :   app_mons_cont ≔ ∅
   END

   PRIME_API_APP_REG   ≙
   STATUS
    ordinary
   REFINES
    PRIME_API_APP_RTM
   ANY
    proc_id       //   application id
   WHERE
    grd1   :   proc_id ∈ pid_t ∧ proc_id ∉ app_sockets
   THEN
    act1   :   app_sockets ≔ app_sockets ∪ {proc_id}
   END

   PRIME_API_APP_KNOB_DISC_manage   ≙
   STATUS
    ordinary
   ANY
    proc_id
    knob
    idd       //   app knob id
   WHERE
    grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
    grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∉ app_knobs_disc
   THEN
    act1   :   app_knobs_disc ≔ app_knobs_disc ∪ {proc_id ↦ idd}
   END
```

```
PRIME_API_APP_KNOB_CONT_manage  ≙
STATUS
  ordinary
ANY
  proc_id
  knob
  idd
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∉ app_knobs_cont
THEN
  act1   :   app_knobs_cont ≔ app_knobs_cont ∪ {proc_id ↦ idd}
END

PRIME_API_APP_MON_DISC_manage  ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∉ app_mons_disc
THEN
  act1   :   app_mons_disc ≔ app_mons_disc ∪ {proc_id ↦ idd}
END

PRIME_API_APP_MON_CONT_manage  ≙
STATUS
  ordinary
ANY
  proc_id
  mon       //
  idd
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∉ app_mons_cont
THEN
  act1   :   app_mons_cont ≔ app_mons_cont ∪ {proc_id ↦ idd}
END

PRIME_API_APP_DEREG  ≙
STATUS
  ordinary
ANY
  proc_id
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   ran(app_knobs_disc) ⊆ app_knobs_disc_t ∧ app_knobs_disc[{proc_id}] = ∅
  grd3   :   ran(app_knobs_cont) ⊆ app_knobs_cont_t ∧ app_knobs_cont[{proc_id}] = ∅
  grd4   :   ran(app_mons_disc) ⊆ app_mons_disc_t ∧ app_mons_disc[{proc_id}] = ∅
  grd5   :   ran(app_mons_cont) ⊆ app_mons_cont_t ∧ app_mons_cont[{proc_id}] = ∅
THEN
  act1   :   app_sockets ≔ app_sockets ∖ {proc_id}
  act2   :   app_knobs_disc ≔ {proc_id} ⩤ app_knobs_disc
  act3   :   app_knobs_cont ≔ {proc_id} ⩤ app_knobs_cont
  act4   :   app_mons_disc ≔ {proc_id} ⩤ app_mons_disc
  act5   :   app_mons_cont ≔ {proc_id} ⩤ app_mons_cont
END
```

```
PRIME_API_DEV_RTM   ≙
 extended
STATUS
 ordinary
REFINES
 PRIME_API_DEV_RTM
BEGIN
 skip
END

PRIME_API_APP_KNOB_DISC_DEREG   ≙
STATUS
 ordinary
ANY
 knob
 proc_id
 idd
WHERE
 grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
THEN
 act1   :   app_knobs_disc ≔ app_knobs_disc \ {proc_id ↦ idd}
END

PRIME_API_APP_KNOB_CONT_DEREG   ≙
STATUS
 ordinary
ANY
 proc_id
 knob
 idd
WHERE
 grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
THEN
 act1   :   app_knobs_cont ≔ app_knobs_cont \ {proc_id ↦ idd}
END

PRIME_API_APP_MON_DISC_DEREG   ≙
STATUS
 ordinary
ANY
 proc_id
 mon
 idd
WHERE
 grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
THEN
 act1   :   app_mons_disc ≔ app_mons_disc \ {proc_id ↦ idd}
END

PRIME_API_APP_MON_CONT_DEREG   ≙
STATUS
 ordinary
ANY
 proc_id
 mon
 idd
WHERE
 grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
THEN
```

```
      act1   :   app_mons_cont ≔ app_mons_cont \ {proc_id ↦ idd}
    END

END
```

```
MACHINE
   machine2      //   refining PRIME_API_APP_KNOB_DISC_manage and PRIME_API_APP_KNOB_CONT_manage
REFINES
   machine1
SEES
   context1
VARIABLES
   app_sockets      //   set of registered applications
   app_knobs_disc      //   set of registered application discrete knobs
   app_knobs_cont      //   set of registered application continuous knobs
   app_mons_disc      //   set of registered application discrete monitors
   app_mons_cont      //   set of registered application continuous monitors
   app_knobs_disc_min
   app_knobs_cont_min
   app_knobs_disc_max
   app_knobs_cont_max
   app_knobs_disc_value
   app_knobs_cont_value
INVARIANTS
   inv1   :   app_knobs_disc_min ∈ app_knobs_disc → ℤ
   inv2   :   app_knobs_cont_min ∈ app_knobs_cont → ℤ
   inv3   :   app_knobs_disc_max ∈ app_knobs_disc → ℤ
   inv4   :   app_knobs_cont_max ∈ app_knobs_cont → ℤ
   inv5   :   app_knobs_disc_value ∈ app_knobs_disc → ℤ
   inv6   :   app_knobs_cont_value ∈ app_knobs_cont → ℤ
EVENTS
   INITIALISATION   ≙
    extended
   STATUS
    ordinary
   BEGIN
    act1   :   app_sockets ≔ ∅
    act2   :   app_knobs_disc ≔ ∅
    act3   :   app_knobs_cont ≔ ∅
    act4   :   app_mons_disc ≔ ∅
    act5   :   app_mons_cont ≔ ∅
    act6   :   app_knobs_disc_min ≔ ∅
    act7   :   app_knobs_cont_min ≔ ∅
    act8   :   app_knobs_disc_max ≔ ∅
    act9   :   app_knobs_cont_max ≔ ∅
    act10   :   app_knobs_disc_value ≔ ∅
    act11   :   app_knobs_cont_value ≔ ∅
   END

   PRIME_API_APP_REG   ≙
    extended
   STATUS
    ordinary
   REFINES
    PRIME_API_APP_REG
   ANY
    proc_id      //   application id
   WHERE
    grd1   :   proc_id ∈ pid_t ∧ proc_id ∉ app_sockets
   THEN
    act1   :   app_sockets ≔ app_sockets ∪ {proc_id}
   END

   PRIME_API_APP_KNOB_DISC_REG   ≙
   STATUS
    ordinary
   REFINES
```

```
 PRIME_API_APP_KNOB_DISC_manage
ANY
 proc_id
 knob
 idd       //   app knob id
 minn
 maxx
WHERE
 grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
 grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∉ app_knobs_disc
 grd3   :   knob ∈ app_knobs_disc_t ∧ minn < maxx
THEN
 act1   :   app_knobs_disc ≔ app_knobs_disc ∪ {proc_id ↦ idd}
 act2   :   app_knobs_disc_min ≔ app_knobs_disc_min ∪ { (proc_id ↦ idd) ↦ minn }
 act3   :   app_knobs_disc_max ≔ app_knobs_disc_max ∪ { (proc_id ↦ idd) ↦ maxx }
 act4   :   app_knobs_disc_value(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_CONT_REG   ≙
STATUS
 ordinary
REFINES
 PRIME_API_APP_KNOB_CONT_manage
ANY
 proc_id
 knob
 idd
 minn
 maxx
WHERE
 grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
 grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∉ app_knobs_cont
 grd3   :   knob ∈ app_knobs_cont_t ∧ minn < maxx
THEN
 act1   :   app_knobs_cont ≔ app_knobs_cont ∪ {proc_id ↦ idd}
 act2   :   app_knobs_cont_min ≔ app_knobs_cont_min ∪ { (proc_id ↦ idd) ↦ minn }
 act3   :   app_knobs_cont_max ≔ app_knobs_cont_max ∪ { (proc_id ↦ idd) ↦ maxx }
 act4   :   app_knobs_cont_value(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_DISC_MIN   ≙
STATUS
 ordinary
ANY
 proc_id
 knob
 idd
 minn
 maxx
 val
WHERE
 grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
            knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ maxx = app_knobs_disc_max
 grd2   :
            (proc_id ↦ idd) ∧ minn < maxx
            knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ val = app_knobs_disc_value
 grd3   :
            (proc_id ↦ idd) ∧ minn ≤ val
THEN
 act1   :   app_knobs_disc_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_CONT_MIN   ≙
STATUS
 ordinary
ANY
 proc_id
```

```
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ maxx = app_knobs_cont_max
             (proc_id ↦ idd) ∧ minn < maxx
  grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ val = app_knobs_cont_value
             (proc_id ↦ idd) ∧ minn ≤ val
THEN
  act1   :   app_knobs_cont_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_DISC_MAX   ≙
STATUS
  ordinary
ANY
  proc_id       //
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
  grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ minn = app_knobs_disc_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ val = app_knobs_disc_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_knobs_disc_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_KNOB_CONT_MAX   ≙
STATUS
  ordinary
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ minn = app_knobs_cont_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ val = app_knobs_cont_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_knobs_cont_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_KNOB_DISC_GET   ≙          //   get value
STATUS
  ordinary
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
```

```
WHERE
 grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
 grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ minn = app_knobs_disc_min
            (proc_id ↦ idd) ∧ minn ≤ val
 grd3   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ maxx = app_knobs_disc_max
            (proc_id ↦ idd) ∧ maxx ≥ val
THEN
 act1   :   app_knobs_disc_value(proc_id ↦ idd) ≔ val
END

PRIME_API_APP_KNOB_CONT_GET  ≙        //  get value
STATUS
 ordinary
ANY
 proc_id
 knob
 idd
 minn
 maxx
 val
WHERE
 grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
 grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ minn = app_knobs_cont_min
            (proc_id ↦ idd) ∧ minn ≤ val
 grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ maxx = app_knobs_cont_max
            (proc_id ↦ idd) ∧ maxx ≥ val
THEN
 act1   :   app_knobs_cont_value(proc_id ↦ idd) ≔ val
END

PRIME_API_APP_KNOB_DISC_DEREG  ≙
STATUS
 ordinary
REFINES
 PRIME_API_APP_KNOB_DISC_DEREG
ANY
 proc_id
 knob
 idd
WHERE
 grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
THEN
 act1   :   app_knobs_disc ≔ app_knobs_disc \ {proc_id ↦ idd}
 act2   :   app_knobs_disc_min ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_min
 act3   :   app_knobs_disc_max ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_max
 act4   :   app_knobs_disc_value ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_value
END

PRIME_API_APP_KNOB_CONT_DEREG  ≙
STATUS
 ordinary
REFINES
 PRIME_API_APP_KNOB_CONT_DEREG
ANY
 proc_id
 knob
 idd
WHERE
 grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
THEN
 act1   :   app_knobs_cont ≔ app_knobs_cont \ {proc_id ↦ idd}
 act2   :   app_knobs_cont_min ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_min
 act3   :   app_knobs_cont_max ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_max
 act4   :   app_knobs_cont_value ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_value
END
```

```
PRIME_API_APP_MON_DISC_manage  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_MON_DISC_manage
ANY
  proc_id
  mon
  idd
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∉ app_mons_disc
THEN
  act1   :   app_mons_disc ≔ app_mons_disc ∪ {proc_id ↦ idd}
END

PRIME_API_APP_MON_CONT_manage  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_MON_CONT_manage
ANY
  proc_id
  mon       //
  idd
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∉ app_mons_cont
THEN
  act1   :   app_mons_cont ≔ app_mons_cont ∪ {proc_id ↦ idd}
END

PRIME_API_APP_DEREG  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_DEREG
ANY
  proc_id
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   ran(app_knobs_disc) ⊆ app_knobs_disc_t ∧ app_knobs_disc[{proc_id}] = ∅
  grd3   :   ran(app_knobs_cont) ⊆ app_knobs_cont_t ∧ app_knobs_cont[{proc_id}] = ∅
  grd4   :   ran(app_mons_disc) ⊆ app_mons_disc_t ∧ app_mons_disc[{proc_id}] = ∅
  grd5   :   ran(app_mons_cont) ⊆ app_mons_cont_t ∧ app_mons_cont[{proc_id}] = ∅
THEN
  act1   :   app_sockets ≔ app_sockets \ {proc_id}
  act2   :   app_knobs_disc ≔ {proc_id} ⩤ app_knobs_disc
  act3   :   app_knobs_cont ≔ {proc_id} ⩤ app_knobs_cont
  act4   :   app_mons_disc ≔ {proc_id} ⩤ app_mons_disc
  act5   :   app_mons_cont ≔ {proc_id} ⩤ app_mons_cont
END

PRIME_API_DEV_RTM  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_DEV_RTM
BEGIN
  skip
```

```
    END

    PRIME_API_APP_MON_DISC_DEREG   ≙
    STATUS
      ordinary
    REFINES
      PRIME_API_APP_MON_DISC_DEREG
    ANY
      proc_id       //
      mon
      idd
    WHERE
      grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
    THEN
      act1   :   app_mons_disc ≔ app_mons_disc \ {proc_id ↦ idd}
    END

    PRIME_API_APP_MON_CONT_DEREG   ≙
    STATUS
      ordinary
    REFINES
      PRIME_API_APP_MON_CONT_DEREG
    ANY
      proc_id
      mon
      idd
    WHERE
      grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
    THEN
      act1   :   app_mons_cont ≔ app_mons_cont \ {proc_id ↦ idd}
    END

END
```

```
MACHINE
   machine3      //   refining PRIME_API_APP_MON_DISC_manage and PRIME_API_APP_MON_CONT_manage
REFINES
   machine2
SEES
   context2
VARIABLES
   app_sockets       //   set of registered applications
   app_knobs_disc       //   set of registered application discrete knobs
   app_knobs_cont       //   set of registered application continuous knobs
   app_mons_disc       //   set of registered application discrete monitors
   app_mons_cont       //   set of registered application continuous monitors
   app_knobs_disc_min
   app_knobs_cont_min
   app_knobs_disc_max
   app_knobs_cont_max
   app_knobs_disc_value
   app_knobs_cont_value
   app_mons_disc_min
   app_mons_cont_min
   app_mons_disc_max
   app_mons_cont_max
   app_mons_disc_weight
   app_mons_cont_weight
   app_mons_disc_value
   app_mons_cont_value
INVARIANTS
   inv1   :   app_mons_disc_min ∈ app_mons_disc ⟶ ℤ
   inv2   :   app_mons_cont_min ∈ app_mons_cont ⟶ ℤ
   inv3   :   app_mons_disc_max ∈ app_mons_disc ⟶ ℤ
   inv4   :   app_mons_cont_max ∈ app_mons_cont ⟶ ℤ
   inv8   :   app_mons_disc_weight ∈ app_mons_disc ⟶ ℤ
   inv7   :   app_mons_cont_weight ∈ app_mons_cont ⟶ ℤ
   inv5   :   app_mons_disc_value ∈ app_mons_disc ⟶ ℤ
   inv6   :   app_mons_cont_value ∈ app_mons_cont ⟶ ℤ
EVENTS
   INITIALISATION   ≙
    extended
   STATUS
    ordinary
   BEGIN
    act1   :   app_sockets ≔ ∅
    act2   :   app_knobs_disc ≔ ∅
    act3   :   app_knobs_cont ≔ ∅
    act4   :   app_mons_disc ≔ ∅
    act5   :   app_mons_cont ≔ ∅
    act6   :   app_knobs_disc_min ≔ ∅
    act7   :   app_knobs_cont_min ≔ ∅
    act8   :   app_knobs_disc_max ≔ ∅
    act9   :   app_knobs_cont_max ≔ ∅
    act10   :   app_knobs_disc_value ≔ ∅
    act11   :   app_knobs_cont_value ≔ ∅
    act12   :   app_mons_disc_min ≔ ∅
    act13   :   app_mons_cont_min ≔ ∅
    act14   :   app_mons_disc_max ≔ ∅
    act15   :   app_mons_cont_max ≔ ∅
    act19   :   app_mons_disc_weight ≔ ∅
    act18   :   app_mons_cont_weight ≔ ∅
    act16   :   app_mons_disc_value ≔ ∅
    act17   :   app_mons_cont_value ≔ ∅
   END
```

```
PRIME_API_APP_REG  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_REG
ANY
  proc_id      //  application id
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∉ app_sockets
THEN
  act1   :   app_sockets ≔ app_sockets ∪ {proc_id}
END

PRIME_API_APP_KNOB_DISC_REG  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_DISC_REG
ANY
  proc_id
  knob
  idd      //  app knob id
  minn
  maxx
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∉ app_knobs_disc
  grd3   :   knob ∈ app_knobs_disc_t ∧ minn < maxx
THEN
  act1   :   app_knobs_disc ≔ app_knobs_disc ∪ {proc_id ↦ idd}
  act2   :   app_knobs_disc_min ≔ app_knobs_disc_min ∪ { (proc_id ↦ idd) ↦ minn }
  act3   :   app_knobs_disc_max ≔ app_knobs_disc_max ∪ { (proc_id ↦ idd) ↦ maxx }
  act4   :   app_knobs_disc_value(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_CONT_REG  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_CONT_REG
ANY
  proc_id
  knob
  idd
  minn
  maxx
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∉ app_knobs_cont
  grd3   :   knob ∈ app_knobs_cont_t ∧ minn < maxx
THEN
  act1   :   app_knobs_cont ≔ app_knobs_cont ∪ {proc_id ↦ idd}
  act2   :   app_knobs_cont_min ≔ app_knobs_cont_min ∪ { (proc_id ↦ idd) ↦ minn }
  act3   :   app_knobs_cont_max ≔ app_knobs_cont_max ∪ { (proc_id ↦ idd) ↦ maxx }
  act4   :   app_knobs_cont_value(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_DISC_MIN  ≙
  extended
STATUS
  ordinary
REFINES
```

```
  PRIME_API_APP_KNOB_DISC_MIN
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
  grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ maxx = app_knobs_disc_max
             (proc_id ↦ idd) ∧ minn < maxx
  grd3   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ val = app_knobs_disc_value
             (proc_id ↦ idd) ∧ minn ≤ val
THEN
  act1   :   app_knobs_disc_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_CONT_MIN   ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_CONT_MIN
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ maxx = app_knobs_cont_max
             (proc_id ↦ idd) ∧ minn < maxx
  grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ val = app_knobs_cont_value
             (proc_id ↦ idd) ∧ minn ≤ val
THEN
  act1   :   app_knobs_cont_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_KNOB_DISC_MAX   ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_DISC_MAX
ANY
  proc_id      //
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
  grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ minn = app_knobs_disc_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ val = app_knobs_disc_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_knobs_disc_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_KNOB_CONT_MAX   ≙
```

```
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_CONT_MAX
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ minn = app_knobs_cont_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ val = app_knobs_cont_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_knobs_cont_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_KNOB_DISC_GET   ≙          //   get value
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_DISC_GET
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
  grd2   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ minn = app_knobs_disc_min
             (proc_id ↦ idd) ∧ minn ≤ val
  grd3   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc ∧ maxx = app_knobs_disc_max
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_knobs_disc_value(proc_id ↦ idd) ≔ val
END

PRIME_API_APP_KNOB_CONT_GET   ≙          //   get value
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_CONT_GET
ANY
  proc_id
  knob
  idd
  minn
  maxx
  val
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
  grd2   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ minn = app_knobs_cont_min
             (proc_id ↦ idd) ∧ minn ≤ val
  grd3   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont ∧ maxx = app_knobs_cont_max
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
```

```
  act1   :   app_knobs_cont_value
             (proc_id ↦ idd) ≔ val
END

PRIME_API_APP_KNOB_DISC_DEREG   ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_DISC_DEREG
ANY
  proc_id
  knob
  idd
WHERE
  grd1   :   knob ∈ app_knobs_disc_t ∧ proc_id ↦ idd ∈ app_knobs_disc
THEN
  act1   :   app_knobs_disc ≔ app_knobs_disc ∖ {proc_id ↦ idd}
  act2   :   app_knobs_disc_min ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_min
  act3   :   app_knobs_disc_max ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_max
  act4   :   app_knobs_disc_value ≔ {proc_id ↦ idd} ⩤ app_knobs_disc_value
END

PRIME_API_APP_KNOB_CONT_DEREG   ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_KNOB_CONT_DEREG
ANY
  proc_id
  knob
  idd
WHERE
  grd1   :   knob ∈ app_knobs_cont_t ∧ proc_id ↦ idd ∈ app_knobs_cont
THEN
  act1   :   app_knobs_cont ≔ app_knobs_cont ∖ {proc_id ↦ idd}
  act2   :   app_knobs_cont_min ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_min
  act3   :   app_knobs_cont_max ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_max
  act4   :   app_knobs_cont_value ≔ {proc_id ↦ idd} ⩤ app_knobs_cont_value
END

PRIME_API_APP_MON_DISC_REG   ≙
STATUS
  ordinary
REFINES
  PRIME_API_APP_MON_DISC_manage
ANY
  proc_id
  mon
  idd       //   app knob id
  minn
  maxx
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∉ app_mons_disc
  grd3   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ minn < maxx
THEN
  act1   :   app_mons_disc ≔ app_mons_disc ∪ {proc_id ↦ idd}
  act2   :   app_mons_disc_min ≔ app_mons_disc_min ∪ { (proc_id ↦ idd) ↦ minn }
  act3   :   app_mons_disc_max ≔ app_mons_disc_max ∪ { (proc_id ↦ idd) ↦ maxx }
END

PRIME_API_APP_MON_CONT_REG   ≙
STATUS
```

```
  ordinary
REFINES
  PRIME_API_APP_MON_CONT_manage
ANY
  proc_id
  mon       //
  idd
  minn
  maxx
WHERE
  grd1   :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∉ app_mons_cont
  grd3   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ minn < maxx
THEN
  act1   :   app_mons_cont ≔ app_mons_cont ∪ {proc_id ↦ idd}
  act2   :   app_mons_cont_min ≔ app_mons_cont_min ∪ { (proc_id ↦ idd) ↦ minn }
  act3   :   app_mons_cont_max ≔ app_mons_cont_max ∪ { (proc_id ↦ idd) ↦ maxx }
END

PRIME_API_APP_MON_DISC_MIN   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
             mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ maxx = app_mons_disc_max
  grd2   :
             (proc_id ↦ idd) ∧ minn < maxx
             mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ val = app_mons_disc_value
  grd3   :
             (proc_id ↦ idd) ∧ minn ≤ val
THEN
  act1   :   app_mons_disc_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_MON_CONT_MIN   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
             mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ maxx = app_mons_cont_max
  grd2   :
             (proc_id ↦ idd) ∧ minn < maxx
             mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ val = app_mons_cont_value
  grd3   :
             (proc_id ↦ idd) ∧ minn ≤ val
THEN
  act1   :   app_mons_cont_min(proc_id ↦ idd) ≔ minn
END

PRIME_API_APP_MON_DISC_MAX   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
  grd2   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ minn = app_mons_disc_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ val = app_mons_disc_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_mons_disc_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_MON_CONT_MAX   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ minn = app_mons_cont_min
             (proc_id ↦ idd) ∧ maxx > minn
  grd3   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ val = app_mons_cont_value
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_mons_cont_max(proc_id ↦ idd) ≔ maxx
END

PRIME_API_APP_MON_DISC_WEIGHT   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  weight
WHERE
  grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
             mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ minn = app_mons_disc_min
  grd2   :   (proc_id ↦ idd) ∧ maxx = app_mons_disc_max
             (proc_id ↦ idd) ∧ minn = MIN_INFINITY ∧ maxx = MAX_INFINITY ∧ weight ≠ 0
THEN
  act1   :   app_mons_disc_weight(proc_id ↦ idd) ≔ weight
END

PRIME_API_APP_MON_CONT_WEIGHT   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  weight
WHERE
  grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ minn = app_mons_cont_min
             (proc_id ↦ idd) ∧ maxx = app_mons_cont_max
             (proc_id ↦ idd) ∧ minn = MIN_INFINITY ∧ maxx = MAX_INFINITY ∧ weight ≠ 0
THEN
  act1   :   app_mons_cont_weight(proc_id ↦ idd) ≔ weight
END

PRIME_API_APP_MON_DISC_SET   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
  grd2   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ minn = app_mons_disc_min
             (proc_id ↦ idd) ∧ minn ≤ val
  grd3   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc ∧ maxx = app_mons_disc_max
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_mons_disc_value(proc_id ↦ idd) ≔ val
END

PRIME_API_APP_MON_CONT_SET   ≙
STATUS
  ordinary
ANY
  proc_id
  mon
  idd
  minn
  maxx
  val
WHERE
  grd1   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
  grd2   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ minn = app_mons_cont_min
             (proc_id ↦ idd) ∧ minn ≤ val
  grd3   :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont ∧ maxx = app_mons_cont_max
             (proc_id ↦ idd) ∧ maxx ≥ val
THEN
  act1   :   app_mons_cont_value(proc_id ↦ idd) ≔ val
END

PRIME_API_APP_MON_DISC_DEREG   ≙
STATUS
  ordinary
REFINES
  PRIME_API_APP_MON_DISC_DEREG
ANY
  proc_id
  mon
  idd
WHERE
  grd1   :   mon ∈ app_mons_disc_t ∧ proc_id ↦ idd ∈ app_mons_disc
THEN
  act1   :   app_mons_disc ≔ app_mons_disc ∖ {proc_id ↦ idd}
  act2   :   app_mons_disc_min ≔ {proc_id ↦ idd} ⩤ app_mons_disc_min
  act3   :   app_mons_disc_max ≔ {proc_id ↦ idd} ⩤ app_mons_disc_max
  act4   :   app_mons_disc_weight ≔ {proc_id ↦ idd} ⩤ app_mons_disc_weight
  act5   :   app_mons_disc_value ≔ {proc_id ↦ idd} ⩤ app_mons_disc_value
END
```

```
PRIME_API_APP_MON_CONT_DEREG  ≙
STATUS
  ordinary
REFINES
  PRIME_API_APP_MON_CONT_DEREG
ANY
  proc_id
  mon
  idd
WHERE
  grd1  :   mon ∈ app_mons_cont_t ∧ proc_id ↦ idd ∈ app_mons_cont
THEN
  act1  :   app_mons_cont ≔ app_mons_cont ∖ {proc_id ↦ idd}
  act2  :   app_mons_cont_min ≔ {proc_id ↦ idd} ⩤ app_mons_cont_min
  act3  :   app_mons_cont_max ≔ {proc_id ↦ idd} ⩤ app_mons_cont_max
  act4  :   app_mons_cont_weight ≔ {proc_id ↦ idd} ⩤ app_mons_cont_weight
  act5  :   app_mons_cont_value ≔ {proc_id ↦ idd} ⩤ app_mons_cont_value
END

PRIME_API_APP_DEREG  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_APP_DEREG
ANY
  proc_id
WHERE
  grd1  :   proc_id ∈ pid_t ∧ proc_id ∈ app_sockets
  grd2  :   ran(app_knobs_disc) ⊆ app_knobs_disc_t ∧ app_knobs_disc[{proc_id}] = ∅
  grd3  :   ran(app_knobs_cont) ⊆ app_knobs_cont_t ∧ app_knobs_cont[{proc_id}] = ∅
  grd4  :   ran(app_mons_disc) ⊆ app_mons_disc_t ∧ app_mons_disc[{proc_id}] = ∅
  grd5  :   ran(app_mons_cont) ⊆ app_mons_cont_t ∧ app_mons_cont[{proc_id}] = ∅
THEN
  act1  :   app_sockets ≔ app_sockets ∖ {proc_id}
  act2  :   app_knobs_disc ≔ {proc_id} ⩤ app_knobs_disc
  act3  :   app_knobs_cont ≔ {proc_id} ⩤ app_knobs_cont
  act4  :   app_mons_disc ≔ {proc_id} ⩤ app_mons_disc
  act5  :   app_mons_cont ≔ {proc_id} ⩤ app_mons_cont
END

PRIME_API_DEV_RTM  ≙
  extended
STATUS
  ordinary
REFINES
  PRIME_API_DEV_RTM
BEGIN
  skip
END

END
```