machine Mach_IPC_Conds

refines Mach_PartProc_Manage **sees** Ctx_IPC

variables processes processes_of_partition partition_mode process_state periodtype_of_process
process_wait_type
locklevel_of_partition
startcondition_of_partition
basepriority_of_process
period_of_process
timecapacity_of_process
deadline_of_process
currentpriority_of_process
deadlinetime_of_process
releasepoint_of_process
delaytime_of_process
current_partition
current_process
current_partition_flag
current_process_flag
clock_tick

need_reschedule
need_procresch
preempter_of_partition
timeout_trigger
errorhandler_of_partition
process_call_errorhandler
queuing_ports
sampling_ports
msgspace_of_samplingports
queue_of_queueingports
processes_waitingfor_queuingports
buffers blackboards semaphores events_ buffers_of_partition blackboards_of_partition semaphores_of_partition events_of_partition MaxMsgNum_of_Buffers queue_of_buffers
processes_waitingfor_buffers
msgspace_of_blackboards emptyindicator_of_blackboards processes_waitingfor_blackboards MaxValue_of_Semaphores
value_of_semaphores
processes_waitingfor_semaphores state_of_events processes_waitingfor_events used_messages

invariants

@inv_used_msgs used_messages ∈ ℙ(**MESSAGES**)

@inv_queuing_ports queuing_ports∈ℙ(**QueuingPorts**)

@inv_sampling_ports sampling_ports∈ℙ(**SamplingPorts**)

@inv_msgsp_sampport msgspace_of_samplingports∈sampling_ports ⇸ (**MESSAGES**×ℕ)

@inv_que_of_queports queue_of_queueingports∈queuing_ports→(**MESSAGES**⇸ℕ)

@inv_que_of_queports_finite ∀*p*·(*p*∈queuing_ports ⇒ finite(queue_of_queueingports(*p*)))

@inv_processes_wf_qports processes_waitingfor_queuingports∈queuing_ports→(processes⇸(**MESSAGES**×ℕ))

@inv_maxnummsg_queports ∀*p*·(*p*∈queuing_ports ⇒ card(queue_of_queueingports(*p*)) ≤ **MaxMsgNum_of_QueuingPorts**(*p*))

@inv_buffers buffers∈ℙ(**BUFFERS**)

@inv_blackboards blackboards∈ℙ(**BLACKBOARDS**)

@inv_semaphores semaphores∈ℙ(**SEMAPHORES**)

@inv_events events_∈ℙ(**EVENTS**)

@inv_buf_part buffers_of_partition ∈ buffers → **PARTITIONS**

@inv_blkb_part blackboards_of_partition ∈ blackboards → **PARTITIONS**

@inv_evt_part events_of_partition ∈ events_ → **PARTITIONS**

@inv_semp_part semaphores_of_partition ∈ semaphores → **PARTITIONS**

@inv_maxnummsg_of_buf MaxMsgNum_of_Buffers ∈ buffers → ℕ1

@inv_queofbuffers queue_of_buffers∈buffers→(**MESSAGES**⇸ℕ)

@inv_queofbuffers_finite ∀*b*·(*b*∈buffers⇒finite(queue_of_buffers(*b*)))

@inv_procswfbuf processes_waitingfor_buffers∈buffers→(processes ⇸ (**MESSAGES**×**BufferWaitingTypes**×ℕ))

@inv_maxnummsg_buffers ∀*p*·(*p*∈buffers ⇒ card(queue_of_buffers(*p*)) ≤ MaxMsgNum_of_Buffers(*p*))

@inv_msgspace_blkb msgspace_of_blackboards∈blackboards ⇸ **MESSAGES**

@inv_emptyind_blkb emptyindicator_of_blackboards ∈ blackboards → **BLACKBOARD_INDICATORTYPE**

@inv_blkb_space_ind ∀*b*·(*b*∈blackboards⇒(emptyindicator_of_blackboards(*b*)=**BB_OCCUPIED** ⇔ *b*∈ dom(msgspace_of_blackboards)))

@inv_procswfblkb processes_waitingfor_blackboards∈blackboards→ℙ(processes)

@inv_maxval_semp MaxValue_of_Semaphores ∈ semaphores → ℕ1

@inv_val_semp value_of_semaphores ∈ semaphores → ℕ

@inv_procswfsemp processes_waitingfor_semaphores ∈ semaphores→(processes⇸ℕ)

@inv_maxvalue_semophare ∀*p*·(*p*∈semaphores ⇒ value_of_semaphores(*p*) ≤ MaxValue_of_Semaphores(*p*))

@inv_stateofevt state_of_events ∈ events_ → **EVENT_STATE**

@inv_procswfevts processes_waitingfor_events ∈ events_ →ℙ(processes)

@inv_processes_wf_qports_part ∀*port*·(*port*∈queuing_ports ⇒ (∀p·(p∈ dom(processes_waitingfor_queuingports(*port*)) ⇒ processes_of_partition(p)=**Ports_of_Partition**(*port*))))

@inv_procswfbuf_part ∀*buf*·(*buf*∈buffers ⇒ (∀p·(p∈dom(processes_waitingfor_buffers(*buf*)) ⇒ processes_of_partition(p)=buffers_of_partition(*buf*))))

@inv_procswfblkb_part ∀*bb*·(*bb*∈blackboards ⇒ (∀p·(p∈processes_waitingfor_blackboards(*bb*) ⇒ processes_of_partition(p)=blackboards_of_partition(*bb*))))

@inv_procstate_waitfor_semophare_part ∀*sem*·(*sem*∈semaphores ⇒ (∀p·(p∈

dom(processes_waitingfor_semaphores(*sem*)) ⇒ processes_of_partition(p)=semaphores_of_partition(*sem*))))

@inv_procswfevts_part ∀*ev*·(*ev*∈events_ ⇒ (∀p·(p∈processes_waitingfor_events(*ev*) ⇒ processes_of_partition(p)=events_of_partition(*ev*))))

events

event INITIALISATION **extends** INITIALISATION

then

@act300 sampling_ports ≔ ∅

@act301 queuing_ports ≔ ∅

@act303 msgspace_of_samplingports ≔ ∅

@act305 queue_of_queueingports ≔ ∅

@act307 processes_waitingfor_queuingports ≔ ∅

@act308 buffers ≔ ∅

@act309 blackboards ≔ ∅

@act310 semaphores ≔ ∅

@act311 events_ ≔ ∅

@act312 buffers_of_partition ≔ ∅

@act313 blackboards_of_partition ≔ ∅

@act314 semaphores_of_partition ≔ ∅

@act3150 events_of_partition ≔ ∅

@act315 MaxMsgNum_of_Buffers ≔ ∅

@act316 queue_of_buffers ≔ ∅

@act317 processes_waitingfor_buffers ≔ ∅

@act319 msgspace_of_blackboards ≔∅

@act320 emptyindicator_of_blackboards ≔ ∅

@act321 processes_waitingfor_blackboards ≔ ∅

@act322 MaxValue_of_Semaphores ≔ ∅

@act323 value_of_semaphores ≔ ∅

@act325 processes_waitingfor_semaphores ≔ ∅

@act326 state_of_events ≔ ∅

@act327 processes_waitingfor_events ≔ ∅

@act328 used_messages ≔ ∅

end

event create_sampling_port

any *port*

where

@grd01 *port*∈**SamplingPorts** ∧ *port*∉sampling_ports

then

@act01 sampling_ports ≔ sampling_ports∪{*port*}

end

event write_sampling_message

any *port msg t*

where

@grd01 $port \in sampling\_ports$

@grd03 **Direction_of_Ports**($port$)=**PORT_SOURCE**

@grd02 $msg \in$ **MESSAGES** $\wedge$ $msg \notin used\_messages$

@grd04 $t \in \mathbb{N}$

then

@act01 $msgspace\_of\_samplingports(port) \coloneqq msg \mapsto t$

@act02 $used\_messages \coloneqq used\_messages \cup \{msg\}$

end

event transfer_sampling_msg

any *p m t*

where

@grd02 $p \in sampling\_ports$

@grd03 $m \in$ **MESSAGES** $\wedge$ $p \in dom(msgspace\_of\_samplingports) \wedge m \mapsto t = msgspace\_of\_samplingports(p)$

@grd06 **Sampling_Channels**$\sim[\{p\}] \subseteq sampling\_ports$

@grd07 $t \in \mathbb{N}$

```
    then
      @act01 msgspace_of_samplingports ≔ msgspace_of_samplingports  (Sampling_Channels~[{p}] × {m↦
t})
  end

  event read_sampling_message
    any port
    where
      @grd01 port∈sampling_ports
      @grd03 Direction_of_Ports(port)=PORT_DESTINATION
      @grd02 port∈dom(msgspace_of_samplingports)
  end

  event create_queuing_port
    any port
    where
      @grd01 port∈QueuingPorts ∧ port ∉queuing_ports
    then
      @act01 queuing_ports ≔ queuing_ports∪{port}
      @act02 queue_of_queueingports(port) ≔ ∅
      @act03 processes_waitingfor_queuingports(port) ≔ ∅
```

end

event send_queuing_message
  any *port msg t*
  where
    @grd01 *port*∈queuing_ports
    @grd03 **Direction_of_Ports**(*port*)=**PORT_SOURCE**
    @grd04 *msg*∈**MESSAGES** ∧ *msg*∉used_messages
    @grd05 card(queue_of_queueingports(*port*))<**MaxMsgNum_of_QueuingPorts**(*port*)
    @grd06 processes_waitingfor_queuingports(*port*) = ∅
    @grd07 *t*∈ℕ
  then
    @act01 queue_of_queueingports(*port*) ≔ queue_of_queueingports(*port*) {*msg*↦*t*}
    @act02 used_messages ≔ used_messages ∪ {*msg*}
end

event transfer_queuing_msg
  any *p m t q que1 que2*
  where
    @grd01 *p*∈queuing_ports ∧ *q*∈ queuing_ports ∧ *p*∈**Source_QueuingPorts**
    @grd02 *q* =**Queuing_Channels**(*p*)

@grd04 $m \in$ **MESSAGES**

@grd05 $m \mapsto t \in$ queue_of_queueingports(p)

@grd06 card(queue_of_queueingports(p)) $\leq$ **MaxMsgNum_of_QueuingPorts**(p) $\wedge$ card(queue_of_queueingports(p)) > 0 $\wedge$ processes_waitingfor_queuingports(p) $= \varnothing$

@grd07 card(queue_of_queueingports(q))<**MaxMsgNum_of_QueuingPorts**(q)

@grd08 $que1 \in$ queuing_ports $\rightarrow$ (**MESSAGES** $\nrightarrow \mathbb{N}$)

@grd09 $que1$ = queue_of_queueingports $\Leftarrow \{p \mapsto$ (queue_of_queueingports(p) $\setminus \{m \mapsto t\})\}$

@grd10 $que2 \in$ queuing_ports $\rightarrow$ (**MESSAGES** $\nrightarrow \mathbb{N}$)

@grd11 $que2 = que1 \Leftarrow \{q \mapsto (que1(q) \Leftarrow \{m \mapsto t\})\}$

then

@act01 queue_of_queueingports $:=$ $que2$

end

event send_queuing_message_needwait **extends** req_busy_resource

any $port$ msg t

where

@grd51 $port \in$ queuing_ports

@grd52 **Ports_of_Partition**($port$) = part

@grd53 **Direction_of_Ports**($port$) = **PORT_SOURCE**

@grd54 $msg \in \mathbf{MESSAGES} \land msg \notin used\_messages$

@grd55 $card(queue\_of\_queueingports(port)) = \mathbf{MaxMsgNum\_of\_QueuingPorts}(port) \lor processes\_waitingfor\_queuingports(port) \neq \varnothing$

@grd56 $t \in \mathbb{N}$

then

@act52 $processes\_waitingfor\_queuingports(port) \coloneqq processes\_waitingfor\_queuingports(port) \Leftarrow \{proc \mapsto (msg \mapsto t)\}$

@act55 $used\_messages \coloneqq used\_messages \cup \{msg\}$

end

event wakeup_waitproc_on_srcqueports **extends** resource_become_available

any *port*

msg *t*

where

@grd501 $port \in queuing\_ports$

@grd502 $\mathbf{Direction\_of\_Ports}(port) = \mathbf{PORT\_SOURCE}$

@grd506 $msg \in \mathbf{MESSAGES}$

@grd503 $t \in \mathbb{N}$

@grd504 $card(queue\_of\_queueingports(port)) < \mathbf{MaxMsgNum\_of\_QueuingPorts}(port)$

@grd505 $(proc \mapsto (msg \mapsto t)) \in processes\_waitingfor\_queuingports(port)$

then

@act501 processes_waitingfor_queuingports(*port*) ≔ {proc} ⩤ processes_waitingfor_queuingports(*port*)
@act506 queue_of_queueingports(*port*) ≔ queue_of_queueingports(*port*) ∪ {*msg* ↦ *t*}

end

event wakeup_waitproc_on_destqueports **extends** resource_become_available

any *port*
msg t

where

@grd501 *port* ∈ queuing_ports
@grd502 **Direction_of_Ports**(*port*) = **PORT_DESTINATION**
@grd503 *msg* ∈ **MESSAGES**
@grd505 *t* ∈ ℕ
@grd504 queue_of_queueingports(*port*) ≠ ∅
@grd506 (proc ↦ (*msg* ↦ *t*)) ∈ processes_waitingfor_queuingports(*port*)

then

@act501 processes_waitingfor_queuingports(*port*) ≔ {proc} ⩤ processes_waitingfor_queuingports(*port*)
@act506 queue_of_queueingports(*port*) ≔ queue_of_queueingports(*port*) ∖ {*msg* ↦ *t*}

end

event receive_queuing_message

any *port*

```
        msg   t

  where
    @grd01 port∈queuing_ports
    @grd03 Direction_of_Ports(port)=PORT_DESTINATION
    @grd04 msg∈MESSAGES
    @grd06 queue_of_queueingports(port)≠∅
    @grd05 (msg ↦t) ∈ queue_of_queueingports(port)
  then
    @act01 queue_of_queueingports(port) ≔ queue_of_queueingports(port)∖{msg ↦   t}
end

event receive_queuing_message_needwait extends req_busy_resource
  any port
        msg   t
  where
    @grd502 port∈queuing_ports
    @grd504 Direction_of_Ports(port)=PORT_DESTINATION
    @grd505 queue_of_queueingports(port)=∅
    @grd506 (msg ↦t) ∈ queue_of_queueingports(port)
  then
```

```
        @act52 processes_waitingfor_queuingports(port) ≔ processes_waitingfor_queuingports(port) {proc↦(msg↦t)}
    end

    event clear_queuing_port
        any port
        where
            @grd01 port∈queuing_ports
            @grd02 Direction_of_Ports(port)=PORT_DESTINATION
        then
            @act01 queue_of_queueingports(port) ≔ ∅
    end

    event create_buffer
        any buf max_msg_size
        where
            @grd00 buf∈BUFFERS ∧ buf∉buffers
            @grd03 max_msg_size∈ℕ1
        then
            @act01 buffers ≔ buffers∪{buf}
            @act02 MaxMsgNum_of_Buffers(buf)≔max_msg_size
```

```
    @act05 queue_of_buffers(buf) ≔ ∅
    @act04 buffers_of_partition(buf) ≔ current_partition
    @act06 processes_waitingfor_buffers(buf) ≔ ∅
end

event send_buffer
  any buf  msg t

  where
    @grd01 buf ∈ buffers
    @grd02 msg∈MESSAGES ∧ msg ∉ used_messages
    @grd05 card(queue_of_buffers(buf))<MaxMsgNum_of_Buffers(buf)
     @grd06 t∈ℕ
  then
    @act01 queue_of_buffers(buf) ≔ queue_of_buffers(buf)  {msg↦t}
    @act05 used_messages ≔ used_messages ∪ {msg}
end

event send_buffer_needwakeuprecvproc extends resource_become_available
  any buf msg
  where
```

@grd502 $buf \in$ buffers
@grd503 $msg \in$ **MESSAGES** $\wedge$ $msg \notin$ used_messages
@grd504 card(queue_of_buffers(buf))<MaxMsgNum_of_Buffers(buf)
@grd505 processes_waitingfor_buffers(buf) $\neq \varnothing$
@grd506 proc$\in$dom(processes_waitingfor_buffers(buf))
then
@act501 used_messages $\coloneqq$ used_messages $\cup$ {msg}
@act502 processes_waitingfor_buffers(buf) $\coloneqq$ {proc} $\lhd$ processes_waitingfor_buffers(buf)
end

event send_buffer_withfull **extends** req_busy_resource
any buf
msg t

where
@grd503 $buf \in$ buffers
@grd501 buffers_of_partition(buf) = part
@grd502 $msg \in$ **MESSAGES** $\wedge$ $msg \notin$ used_messages
@grd505 card(queue_of_buffers(buf))=MaxMsgNum_of_Buffers(buf)
@grd506 $t \in \mathbb{N}$
then

```
    @act501 used_messages ≔ used_messages ∪ {msg}
    @act502 processes_waitingfor_buffers(buf) ≔ processes_waitingfor_buffers(buf) {proc ↦(msg↦
WAITING_W↦t)}
  end

  event receive_buffer
    any buf
        msg  t

    where
      @grd01 buf ∈ buffers
      @grd03 queue_of_buffers(buf)≠∅
      @grd05 (msg ↦t) ∈ queue_of_buffers(buf)
    then
      @act01 queue_of_buffers(buf) ≔ queue_of_buffers(buf) ∖ {msg↦t}
  end

  event receive_buffer_needwakeupsendproc extends resource_become_available
    any buf msg t m t_
    where
      @grd506 buf ∈ buffers
```

@grd502 $msg \in$ **MESSAGES** $\land$ $m \in$ **MESSAGES** $\land$ $t \in \mathbb{N}$ $\land$ $t\_ \in \mathbb{N}$

@grd503 queue_of_buffers(buf) $\neq \varnothing$

@grd505 processes_waitingfor_buffers(buf) $\neq \varnothing$ $\land$ (proc $\mapsto$ ($m \mapsto$ **WAITING_W** $\mapsto t\_$)) $\in$ processes_waitingfor_buffers(buf)

@grd507 ($msg \mapsto t$) $\in$ queue_of_buffers(buf)

then

@act501 queue_of_buffers(buf) $\coloneqq$ queue_of_buffers(buf) $\setminus$ {$msg \mapsto t$}

@act502 processes_waitingfor_buffers(buf) $\coloneqq$ {proc} $\lhd$ processes_waitingfor_buffers(buf)

end

event receive_buffer_whenempty **extends** req_busy_resource

any *buf*

msg *t*

where

@grd504 $buf \in$ buffers

@grd501 buffers_of_partition(buf) = part

@grd502 queue_of_buffers(buf) $= \varnothing$

@grd503 $msg \in$ **MESSAGES**

@grd505 $t \in \mathbb{N}$

```
    then
      @act501 processes_waitingfor_buffers(buf) ≔ processes_waitingfor_buffers(buf) ⩤ {proc ↦ (msg ↦
WAITING_R ↦ t)}
  end

  event create_blackboard
    any bb
    where
      @grd00 bb ∈ BLACKBOARDS ∧ bb ∉ blackboards
    then
      @act01 blackboards ≔ blackboards ∪ {bb}
      @act04 emptyindicator_of_blackboards(bb) ≔ BB_EMPTY
      @act03 blackboards_of_partition(bb) ≔ current_partition
      @act05 processes_waitingfor_blackboards(bb) ≔ ∅
  end

  event display_blackboard
    any bb msg
    where
      @grd00 bb ∈ blackboards
      @grd02 msg ∈ MESSAGES ∧ msg ∉ used_messages
```

@grd03 processes_waitingfor_blackboards(*bb*) = ∅

then

@act01 msgspace_of_blackboards(*bb*) ≔ *msg*

@act02 used_messages ≔ used_messages ∪ {*msg*}

@act03 emptyindicator_of_blackboards(*bb*) ≔ **BB_OCCUPIED**

end

event display_blackboard_needwakeuprdprocs **extends** resource_become_available2

any *bb msg*

where

@grd500 *bb*∈blackboards

@grd501 blackboards_of_partition(*bb*) = part

@grd504 *msg*∈**MESSAGES** ∧ *msg*∉used_messages

@grd505 processes_waitingfor_blackboards(*bb*) ≠ ∅

@grd506 procs = processes_waitingfor_blackboards(*bb*)

then

@act501 msgspace_of_blackboards(*bb*) ≔ *msg*

@act502 processes_waitingfor_blackboards(*bb*) ≔ processes_waitingfor_blackboards(*bb*)∖procs

@act504 used_messages ≔ used_messages ∪ {*msg*}

@act503 emptyindicator_of_blackboards(*bb*) ≔ **BB_OCCUPIED**

end

```
event read_blackboard
  any bb msg
  where
    @grd00 bb∈blackboards
    @grd02 msg∈MESSAGES
    @grd03 emptyindicator_of_blackboards(bb) = BB_OCCUPIED
end

event read_blackboard_whenempty extends req_busy_resource
  any bb
  where
    @grd500 bb∈blackboards
    @grd501 blackboards_of_partition(bb) = part
    @grd502 emptyindicator_of_blackboards(bb) = BB_EMPTY
  then
    @act501 processes_waitingfor_blackboards(bb) ≔ processes_waitingfor_blackboards(bb) ∪ {proc}
end

event clear_blackboard
  any bb
```

```
  where
    @grd00 bb∈blackboards
  then
    @act01 emptyindicator_of_blackboards(bb) ≔ BB_EMPTY
    @act02 msgspace_of_blackboards ≔ {bb} ⩤ msgspace_of_blackboards
end

event create_semaphore
  any sem maxval currentval
  where
    @grd01 sem∈SEMAPHORES ∧ sem∉semaphores
    @grd07 maxval∈ℕ1
    @grd08 currentval∈ℕ ∧ currentval≤maxval
  then
    @act01 semaphores ≔ semaphores∪{sem}
    @act03 value_of_semaphores(sem)≔currentval
    @act04 MaxValue_of_Semaphores(sem)≔maxval
    @act05 semaphores_of_partition(sem) ≔current_partition
    @act06 processes_waitingfor_semaphores(sem) ≔ ∅
end
```

event wait_semaphore
  any *sem*
  where
    @grd00 $sem \in semaphores$
    @grd02 $value\_of\_semaphores(sem) > 0$
  then
    @act01 $value\_of\_semaphores(sem) \coloneqq value\_of\_semaphores(sem) - 1$
end

event wait_semahpore_whenzero **extends** req_busy_resource
  any *sem* *t*

  where
    @grd500 $sem \in semaphores$
    @grd502 $semaphores\_of\_partition(sem) = part$
    @grd504 $value\_of\_semaphores(sem) = 0$
    @grd501 $t \in \mathbb{N}$
  then
    @act501 $processes\_waitingfor\_semaphores(sem) \coloneqq processes\_waitingfor\_semaphores(sem) \quad \{proc \mapsto t\}$
end

```
event signal_semaphore
  any sem
  where
    @grd00 sem∈semaphores
    @grd02 value_of_semaphores(sem) ≠ MaxValue_of_Semaphores(sem)
    @grd03 processes_waitingfor_semaphores(sem) = ∅
  then
    @act01 value_of_semaphores(sem) ≔ value_of_semaphores(sem) + 1
end

event signal_semaphore_needwakeupproc extends resource_become_available
  any sem // t

  where
    @grd500 sem∈semaphores
    @grd503 value_of_semaphores(sem) ≠ MaxValue_of_Semaphores(sem)
    @grd506 processes_waitingfor_semaphores(sem) ≠ ∅
  then
    @act501 processes_waitingfor_semaphores(sem) ≔ {proc} ⩤ processes_waitingfor_semaphores(sem)
end
```

```
event create_event
  any ev
  where
    @grd01 ev∈EVENTS ∧ ev ∉ events_
  then
    @act01 events_ ≔ events_∪{ev}
    @act02 state_of_events(ev) ≔ EVENT_DOWN
    @act03 events_of_partition(ev) ≔ current_partition
    @act04 processes_waitingfor_events(ev) ≔ ∅
end

event set_event
  any ev
  where
    @grd00 ev∈events_
    @grd03 processes_waitingfor_events(ev) = ∅
  then
    @act01 state_of_events(ev)≔EVENT_UP
end

event set_event_needwakeupprocs extends resource_become_available2
```

```
  any ev
  where
    @grd500 ev∈events_
    @grd503 processes_waitingfor_events(ev) ≠ ∅
  then
    @act501 state_of_events(ev)≔EVENT_UP
    @act503 processes_waitingfor_events(ev) ≔ processes_waitingfor_events(ev)∖procs
end

event reset_event
  any ev
  where
    @grd00 ev∈events_
  then
    @act01 state_of_events(ev)≔EVENT_DOWN
end

event wait_event
  any ev
  where
    @grd00 ev∈events_
```

```
    @grd02 state_of_events(ev)=EVENT_UP
end

event wait_event_whendown extends req_busy_resource
  any ev
  where
    @grd500 ev∈events_
    @grd502 events_of_partition(ev) = part
    @grd504 state_of_events(ev)=EVENT_DOWN
  then
    @act501 processes_waitingfor_events(ev) ≔ processes_waitingfor_events(ev) ∪ {proc}
end

event ticktock
extends ticktock
end

event partition_schedule extends partition_schedule
end

event process_schedule
```

```
  extends process_schedule
  end

  event run_errorhandler_preempter
  extends run_errorhandler_preempter
  end

  event get_partition_status extends get_partition_status
  end

  event set_partition_mode_to_idle
  extends set_partition_mode_to_idle
    then
      @act501 queuing_ports ≔ queuing_ports⩥Ports_of_Partition~[{part}]
      @act502 sampling_ports ≔ sampling_ports⩥Ports_of_Partition~[{part}]
      @act503 msgspace_of_samplingports ≔  Ports_of_Partition~[{part}] ⩤ msgspace_of_samplingports
      @act505 queue_of_queueingports ≔ Ports_of_Partition~[{part}] ⩤ queue_of_queueingports
      @act507 processes_waitingfor_queuingports ≔ Ports_of_Partition~[{part}] ⩤
processes_waitingfor_queuingports
      @act508 buffers ≔ buffers⩥buffers_of_partition~[{part}]
      @act509 blackboards ≔ blackboards⩥blackboards_of_partition~[{part}]
```

```
        @act510 semaphores ≔ semaphores∖semaphores_of_partition~[{part}]
        @act511 events_ ≔ events_∖events_of_partition~[{part}]
        @act512 buffers_of_partition ≔ buffers_of_partition⩤{part}
        @act513 blackboards_of_partition ≔ blackboards_of_partition⩤{part}
        @act514 semaphores_of_partition ≔ semaphores_of_partition⩤{part}
        @act515 events_of_partition ≔ events_of_partition⩤{part}
        @act516 MaxMsgNum_of_Buffers ≔ buffers_of_partition~[{part}] ⩤ MaxMsgNum_of_Buffers
        @act517 queue_of_buffers ≔ buffers_of_partition~[{part}] ⩤ queue_of_buffers
        @act518 processes_waitingfor_buffers ≔ buffers_of_partition~[{part}] ⩤ processes_waitingfor_buffers
        @act520 msgspace_of_blackboards ≔ blackboards_of_partition~[{part}]⩤ msgspace_of_blackboards
        @act521 emptyindicator_of_blackboards ≔ blackboards_of_partition~[{part}] ⩤
emptyindicator_of_blackboards
        @act522 processes_waitingfor_blackboards ≔ blackboards_of_partition~[{part}] ⩤
processes_waitingfor_blackboards
        @act523 MaxValue_of_Semaphores ≔ semaphores_of_partition~[{part}] ⩤ MaxValue_of_Semaphores
        @act524 value_of_semaphores ≔ semaphores_of_partition~[{part}] ⩤ value_of_semaphores
        @act526 processes_waitingfor_semaphores ≔ semaphores_of_partition~[{part}] ⩤
processes_waitingfor_semaphores
        @act527 state_of_events ≔ events_of_partition~[{part}] ⩤ state_of_events
        @act528 processes_waitingfor_events ≔ events_of_partition~[{part}] ⩤ processes_waitingfor_events
    end
```

```
  event set_partition_mode_to_normal extends set_partition_mode_to_normal
  end

  event set_partition_mode_to_coldstart extends set_partition_mode_to_coldstart
    then
      @act501 queuing_ports ≔ queuing_ports∖Ports_of_Partition~[{part}]
      @act502 sampling_ports ≔ sampling_ports∖Ports_of_Partition~[{part}]
      @act503 msgspace_of_samplingports ≔  Ports_of_Partition~[{part}] ⩤ msgspace_of_samplingports
      @act505 queue_of_queueingports ≔ Ports_of_Partition~[{part}] ⩤ queue_of_queueingports
      @act507 processes_waitingfor_queuingports ≔ Ports_of_Partition~[{part}] ⩤
processes_waitingfor_queuingports
      @act508 buffers ≔ buffers∖buffers_of_partition~[{part}]
      @act509 blackboards ≔ blackboards∖blackboards_of_partition~[{part}]
      @act510 semaphores ≔ semaphores∖semaphores_of_partition~[{part}]
      @act511 events_ ≔ events_∖events_of_partition~[{part}]
      @act512 buffers_of_partition ≔ buffers_of_partition⩥{part}
      @act513 blackboards_of_partition ≔ blackboards_of_partition⩥{part}
      @act514 semaphores_of_partition ≔ semaphores_of_partition⩥{part}
      @act515 events_of_partition ≔ events_of_partition⩥{part}
      @act516 MaxMsgNum_of_Buffers ≔ buffers_of_partition~[{part}] ⩤ MaxMsgNum_of_Buffers
```

@act517 queue_of_buffers ≔ buffers_of_partition~[{part}] ⩤ queue_of_buffers

@act518 processes_waitingfor_buffers ≔ buffers_of_partition~[{part}] ⩤ processes_waitingfor_buffers

@act520 msgspace_of_blackboards ≔ blackboards_of_partition~[{part}]⩤ msgspace_of_blackboards

@act521 emptyindicator_of_blackboards ≔ blackboards_of_partition~[{part}] ⩤ emptyindicator_of_blackboards

@act522 processes_waitingfor_blackboards ≔ blackboards_of_partition~[{part}] ⩤ processes_waitingfor_blackboards

@act523 MaxValue_of_Semaphores ≔ semaphores_of_partition~[{part}] ⩤ MaxValue_of_Semaphores

@act524 value_of_semaphores ≔ semaphores_of_partition~[{part}] ⩤ value_of_semaphores

@act526 processes_waitingfor_semaphores ≔ semaphores_of_partition~[{part}] ⩤ processes_waitingfor_semaphores

@act527 state_of_events ≔ events_of_partition~[{part}] ⩤ state_of_events

@act528 processes_waitingfor_events ≔ events_of_partition~[{part}] ⩤ processes_waitingfor_events

end

event set_partition_mode_to_warmstart **extends** set_partition_mode_to_warmstart

then

@act501 queuing_ports ≔ queuing_ports⩥**Ports_of_Partition**~[{part}]

@act502 sampling_ports ≔ sampling_ports⩥**Ports_of_Partition**~[{part}]

@act503 msgspace_of_samplingports ≔ **Ports_of_Partition**~[{part}] ⩤ msgspace_of_samplingports

@act505 queue_of_queueingports ≔ **Ports_of_Partition**~[{part}] ⩤ queue_of_queueingports

@act507 processes_waitingfor_queuingports ≔ **Ports_of_Partition**~[{part}] ⩤ processes_waitingfor_queuingports

@act508 buffers ≔ buffers∖buffers_of_partition~[{part}]

@act509 blackboards ≔ blackboards∖blackboards_of_partition~[{part}]

@act510 semaphores ≔ semaphores∖semaphores_of_partition~[{part}]

@act511 events_ ≔ events_∖events_of_partition~[{part}]

@act512 buffers_of_partition ≔ buffers_of_partition⩥{part}

@act513 blackboards_of_partition ≔ blackboards_of_partition⩥{part}

@act514 semaphores_of_partition ≔ semaphores_of_partition⩥{part}

@act515 events_of_partition ≔ events_of_partition⩥{part}

@act516 MaxMsgNum_of_Buffers ≔ buffers_of_partition~[{part}] ⩤ MaxMsgNum_of_Buffers

@act517 queue_of_buffers ≔ buffers_of_partition~[{part}] ⩤ queue_of_buffers

@act518 processes_waitingfor_buffers ≔ buffers_of_partition~[{part}] ⩤ processes_waitingfor_buffers

@act520 msgspace_of_blackboards ≔ blackboards_of_partition~[{part}]⩤ msgspace_of_blackboards

@act521 emptyindicator_of_blackboards ≔ blackboards_of_partition~[{part}] ⩤ emptyindicator_of_blackboards

@act522 processes_waitingfor_blackboards ≔ blackboards_of_partition~[{part}] ⩤ processes_waitingfor_blackboards

@act523 MaxValue_of_Semaphores ≔ semaphores_of_partition~[{part}] ⩤ MaxValue_of_Semaphores

@act524 value_of_semaphores ≔ semaphores_of_partition~[{part}] ⩤ value_of_semaphores

@act526 processes_waitingfor_semaphores ≔ semaphores_of_partition~[{part}] ⩤

```
processes_waitingfor_semaphores
        @act527 state_of_events ≔ events_of_partition~[{part}] ⩤ state_of_events
        @act528 processes_waitingfor_events ≔ events_of_partition~[{part}] ⩤ processes_waitingfor_events
    end

    event get_process_id extends get_process_id
    end

    event get_process_status extends get_process_status
    end

    event create_process extends create_process
    end

    event set_priority extends set_priority
    end

    event suspend_self
    extends suspend_self
    end
```

event suspend
extends suspend
end

event resume
extends resume
end

event stop_self **extends** stop_self
end

event stop **extends** stop
when
@grd50 ¬(∃r·r∈queuing_ports ∧ proc∈dom(processes_waitingfor_queuingports(r)))
@grd51 ¬(∃r·r∈buffers ∧ proc∈dom(processes_waitingfor_buffers(r)))
@grd52 ¬(∃r·r∈semaphores ∧ proc∈dom(processes_waitingfor_semaphores(r)))
@grd53 ¬(∃r·r∈blackboards ∧ proc∈processes_waitingfor_blackboards(r))
@grd54 ¬(∃r·r∈events_ ∧ proc∈processes_waitingfor_events(r))
end

event stop_wf_qport **extends** stop

```
  any r
  where
    @grd50 r∈queuing_ports ∧ proc∈dom(processes_waitingfor_queuingports(r))
  then
     @act501 processes_waitingfor_queuingports ≔ (processes_waitingfor_queuingports  {r↦
({proc}⩤processes_waitingfor_queuingports(r))})
  end

  event stop_wf_buf extends stop
  any r
  where
    @grd50 r∈buffers ∧ proc∈dom(processes_waitingfor_buffers(r))
  then
     @act501 processes_waitingfor_buffers ≔ (processes_waitingfor_buffers  {r↦
({proc}⩤processes_waitingfor_buffers(r))})
  end

  event stop_wf_sem extends stop
  any r
  where
    @grd50 r∈semaphores ∧ proc∈dom(processes_waitingfor_semaphores(r))
```

then

@act501 processes_waitingfor_semaphores ≔ (processes_waitingfor_semaphores ⩤ {r ↦ ({proc}⩤processes_waitingfor_semaphores(r))})

end

event stop_wf_bb **extends** stop

any r

where

@grd50 r∈blackboards ∧ proc∈processes_waitingfor_blackboards(r)

then

@act501 processes_waitingfor_blackboards ≔ processes_waitingfor_blackboards ⩤ {r ↦ (processes_waitingfor_blackboards(r)∖{proc})}

end

event stop_wf_evt **extends** stop

any r

where

@grd50 r∈events_ ∧ proc∈processes_waitingfor_events(r)

then

@act501 processes_waitingfor_events ≔ processes_waitingfor_events ⩤ {r ↦ (processes_waitingfor_events(r)∖{proc})}

```
end

event start_aperiodprocess_instart
extends start_aperiodprocess_instart
end

event start_aperiodprocess_innormal
extends start_aperiodprocess_innormal
end

event start_periodprocess_instart
extends start_periodprocess_instart
end

event start_periodprocess_innormal
extends start_periodprocess_innormal
end

event delaystart_aperiodprocess_instart
extends delaystart_aperiodprocess_instart
end
```

```
event delaystart_aperiodprocess_innormal
extends delaystart_aperiodprocess_innormal
end

event delaystart_periodprocess_instart
extends delaystart_periodprocess_instart
end

event delaystart_periodprocess_innormal
extends delaystart_periodprocess_innormal
end

event lock_preemption extends lock_preemption
end

event unlock_preemption extends unlock_preemption
end

event get_my_id extends get_my_id
end
```

```
event timed_wait extends timed_wait
end

event period_wait extends period_wait
end

event get_time extends get_time
end

event replenish extends replenish
end

event aperiodicprocess_finished extends aperiodicprocess_finished
end

event periodicprocess_finished extends periodicprocess_finished
end


event time_out extends time_out
```

when

@grd50 ¬(∃r·r∈queuing_ports ∧ proc∈dom(processes_waitingfor_queuingports(r)))

@grd51 ¬(∃r·r∈buffers ∧ proc∈dom(processes_waitingfor_buffers(r)))

@grd52 ¬(∃r·r∈semaphores ∧ proc∈dom(processes_waitingfor_semaphores(r)))

@grd53 ¬(∃r·r∈blackboards ∧ proc∈processes_waitingfor_blackboards(r))

@grd54 ¬(∃r·r∈events_ ∧ proc∈processes_waitingfor_events(r))

end

event time_out_wf_qport **extends** time_out

any *r*

where

@grd50 *r*∈queuing_ports ∧ proc∈dom(processes_waitingfor_queuingports(*r*))

then

@act501 processes_waitingfor_queuingports ≔ (processes_waitingfor_queuingports {*r*↦ ({proc}⩤processes_waitingfor_queuingports(*r*))})

end

event time_out_wf_buf **extends** time_out

any *r*

where

@grd50 *r*∈buffers ∧ proc∈dom(processes_waitingfor_buffers(*r*))

then

@act501 processes_waitingfor_buffers ≔ (processes_waitingfor_buffers ∖ {r ↦ ({proc}⩤processes_waitingfor_buffers(r))})

end

event time_out_wf_sem **extends** time_out

any *r*

where

@grd50 *r*∈semaphores ∧ proc∈dom(processes_waitingfor_semaphores(*r*))

then

@act501 processes_waitingfor_semaphores ≔ (processes_waitingfor_semaphores ∖ {r ↦ ({proc}⩤processes_waitingfor_semaphores(r))})

end

event time_out_wf_bb **extends** time_out

any *r*

where

@grd50 *r*∈blackboards ∧ proc∈processes_waitingfor_blackboards(*r*)

then

@act501 processes_waitingfor_blackboards ≔ processes_waitingfor_blackboards ∖ {r ↦ (processes_waitingfor_blackboards(r)∖{proc})}

```
  end

  event time_out_wf_evt extends time_out
  any r
  where
    @grd50 r∈events_  ∧ proc∈processes_waitingfor_events(r)
  then
    @act501 processes_waitingfor_events ≔ processes_waitingfor_events  {r↦(processes_waitingfor_events(r)∖
{proc})}
  end

  event periodicproc_reach_releasepoint extends periodicproc_reach_releasepoint
  end

  event coldstart_partition_fromidle extends coldstart_partition_fromidle
  end

  event warmstart_partition_fromidle extends warmstart_partition_fromidle
  end
end
```