Fault tolerance in Composite

Formula

Assumption:
1) Asusme system has N tasks that need to be rebuilt during the recovery
2) $j < i$ indicates that task$_j$ has higher priority
3) For checkpoint, now assume one component is checkpointed, and 4 threads within (also Checkpoint is atomic)
4) Assume each task has the same number objects to recover for now, e.g, same n

- Checkpoint (system service is checked, atomic operation)

$$R_i^{n+1} = b_i + e_i + \sum_{j<i} \lceil \frac{R_i^n}{p_j} \rceil e_j + \lceil \frac{R_i^n}{p_{chk}} \rceil e_{chk} + \lceil \frac{R_i^n}{p_{re}} \rceil r_{chk} \tag{1}$$

  - e_{chk} and r_{chk} depend on how many objects, e.g, threads, and files, etc., checkpointed/restored

- Eager recovery

$$R_i^{n+1} = b_i + e_i + \sum_{j<i} \lceil \frac{R_i^n}{p_j} \rceil e_j + \lceil \frac{R_i^n}{p_{re}} \rceil (e_{\mu r} + \sum_{j=1}^{N} r_j(n)) \tag{2}$$

- On-Demand recovery

$$R_i^{n+1} = b_i + e_i + \sum_{j<i} \lceil \frac{R_i^n}{p_j} \rceil e_j + \lceil \frac{R_i^n}{p_{re}} \rceil (e_{\mu r} + \sum_{j \leq i} r_j(n)) \tag{3}$$

One Equation

$$R_i^{n+1} = e_i + b_i + \sum_{j<i} \lceil \frac{R_i^n}{p_j} \rceil e_j + \lceil \frac{R_i^n}{p_{re}} \rceil e_{\mu r} + \lceil \frac{R_i^n}{p_{re}} \rceil \begin{cases} r_{chk} + \lceil \frac{R_i^n}{p_{re}} \rceil^{-1} \lceil \frac{R_i^n}{p_{chk}} \rceil e_{chk} & \text{checkpoint} \\ \sum_{j=1}^{N} r_j(n) & \text{eager} \\ \sum_{j=1}^{i} r_j(n) & \text{on-demand} \end{cases}$$

Variables

Assumption:
1) RMS
2)$j < i$ implies that task$_j$ has smaller period and higer priority than task$_i$, j starts from 1

- Regular Definition
  - $R_i \equiv$ response time of task i
  - $e_i \equiv$ execution time of task i
  - $d_i \equiv$ deadline of task i
  - $p_i \equiv$ period of task i
  - $b_i \equiv$ blocking time of task i (caused by the lower priority tasks)
- Fault Related
  - $p_{re} \equiv$ period of fault
  - $e^x_{\mu r} \equiv$ execution time of the micro rebooting spd c^x
  - $e_{\mu r} \equiv \max_{\forall x}\{e^x_{\mu r}\}$
  - $r^x_j(n) \equiv$ n objects recovery cost for task t_j if component c^x failed
  - $r_j(n) \equiv \max_{\forall x}\{r^x_j(n)\}$
  - CheckPointing
    - $p_{chk} \equiv$ period of checkpointing
    - $e_{chk} \equiv$ cost of saving checkpoint
    - $r_{chk} \equiv$ cost of restoring from the checkpoint

Parameters

- Recovery
  - OD
  - EG
  - CK
- Period
  - P_{task}
  - P_{fault}
  - P_{ckpt}
- Number
  - Obj_{num}
  - Task_{num}
  - **Util**
- Cost
  - $\mathrm{PerObjRec}_{cost}$
  - $\mathrm{CheckSave}_{cost} = \mathrm{CheckRestore}_{cost}$
  - $\mu\mathbf{Reboot}_{cost}$