Tickless Round Robin

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Constraints at Fitbit

- Memory
- Power
- Time critical tasks - sensor acquisition, algorithms
- Many user facing tasks that need to share the cpu fairly

Tick or tickless?

What is a tick?

- A periodic timer ➔ wakes the system to check for pending events.

- The timer ISR has two jobs:
  - Handle expired timers.
  - Handle the scheduling policy.

- Timer period is a trade-off between precision and power efficiency.

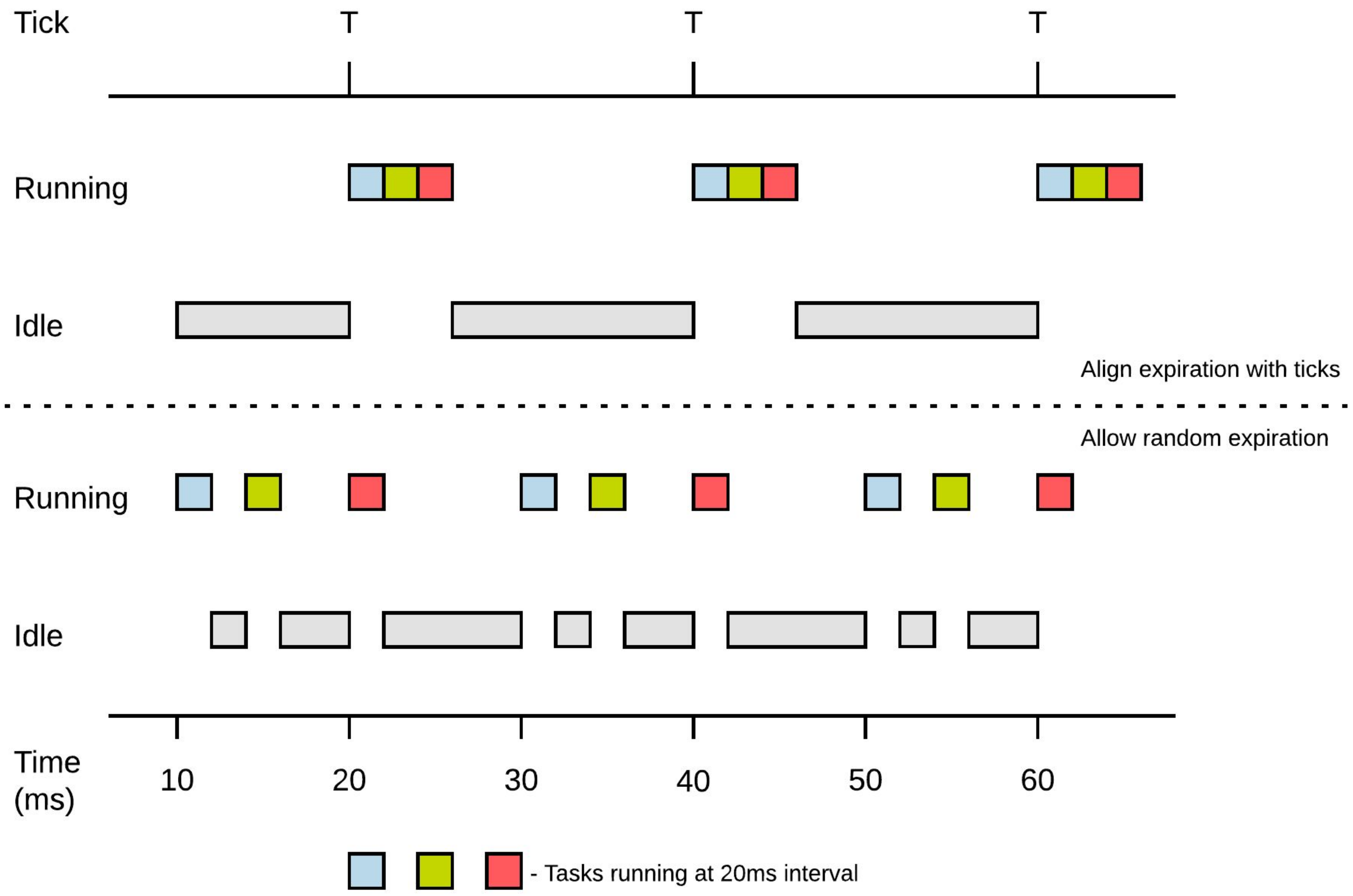
Introducing tickless

- Replace periodic timer ➔ one-shot timer dynamically set to fire on the next event.

- Idle system ➔ timer doesn't need to trigger at all.

- System can respond to events rapidly when needed and sleep in idle periods.

The ticks in tickless



Scheduling Policy

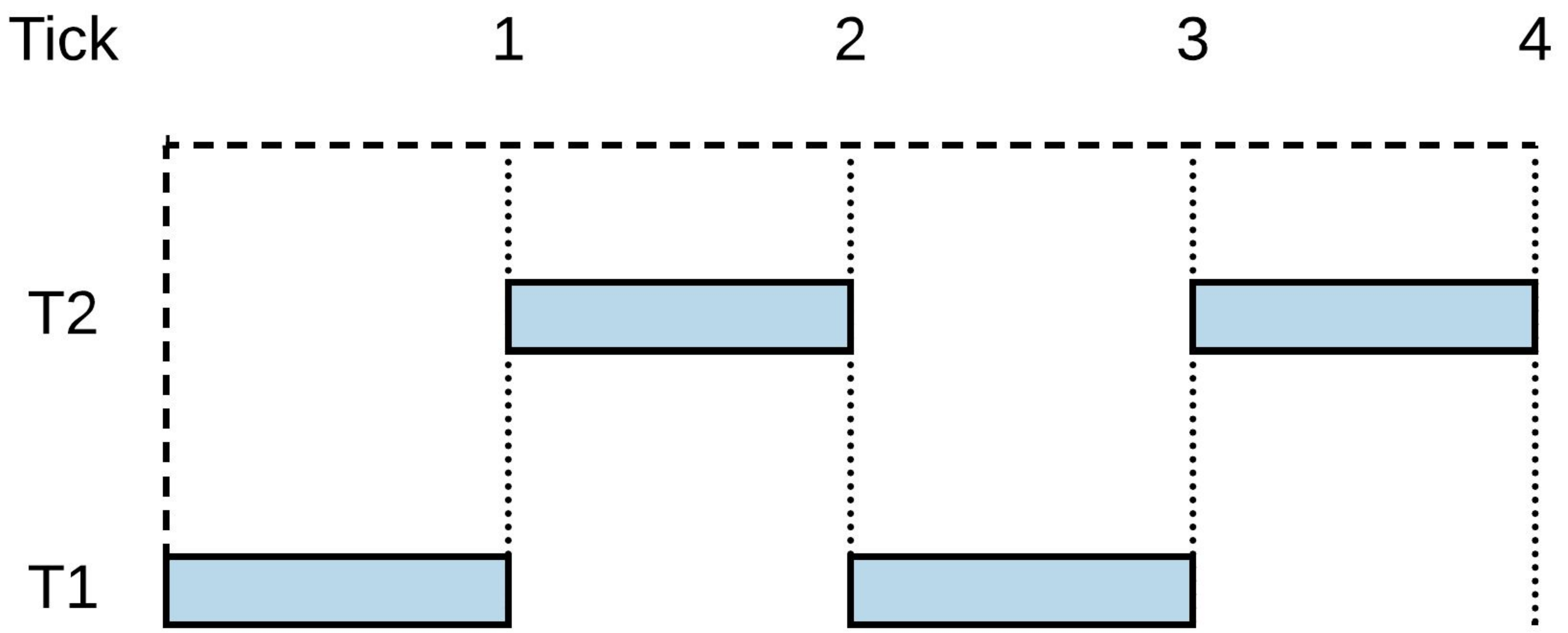
NuttX Scheduling Policies

- Preemptive RTOS ➔ priority is strictly enforced.
- Tasks with equal priority execute FIFO.
- Round robin policy available.

Round Robin Policy

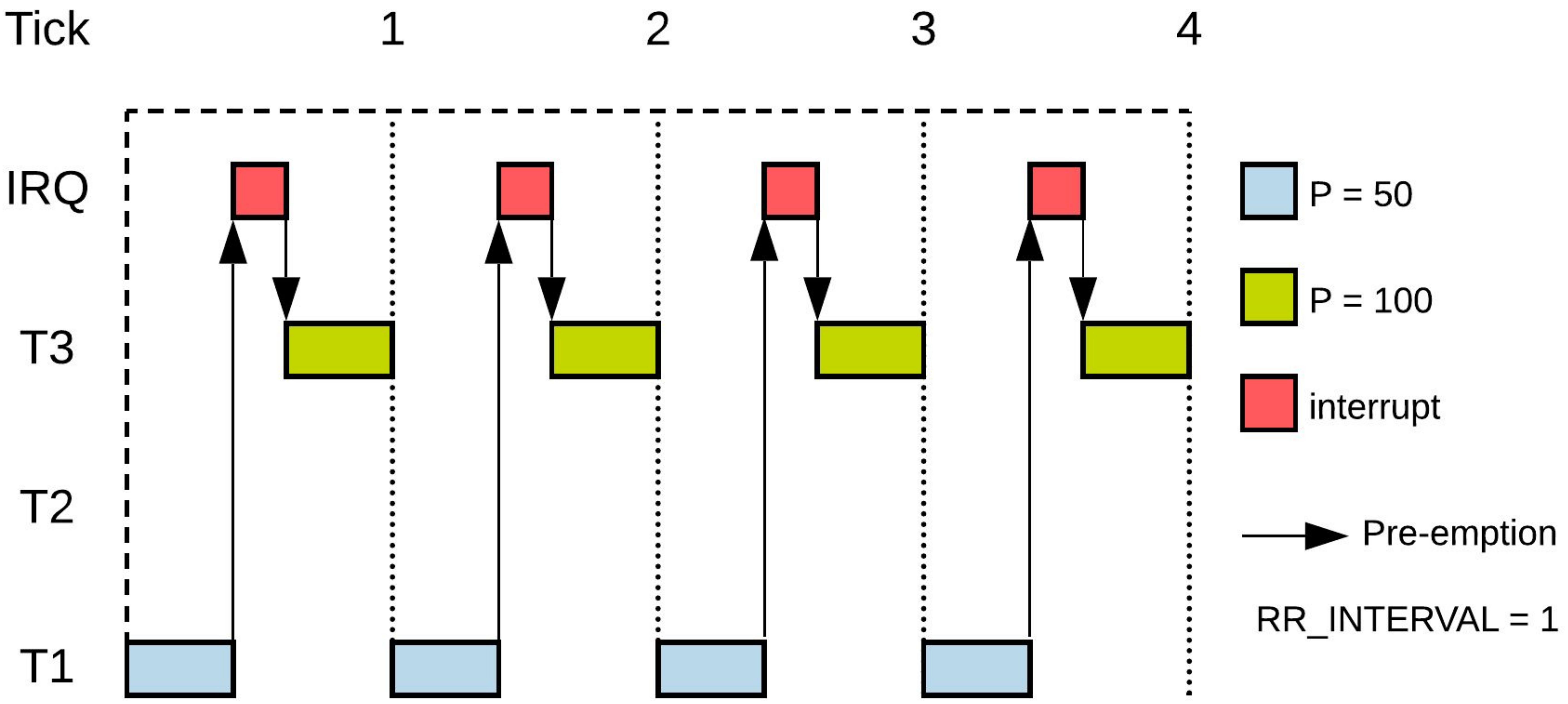
- Each task is assigned a RR_INTERVAL timeslice.
- When the time slice elapses, swap the task with the next task of equal priority.

Round Robin in Action



RR_INTERVAL = 1

What if we get preempted?



Limitations

- Tasks are guaranteed to execute at least RR_INTERVAL, but...
- Tasks waiting in line can potentially wait indefinitely to be scheduled.

Can we do better?

- Naive solution → swap task when it gets preempted.
- Unfair to the interrupted task → it doesn’t get to complete its time slice.
- Better solution → carry remaining slice when task resumes.

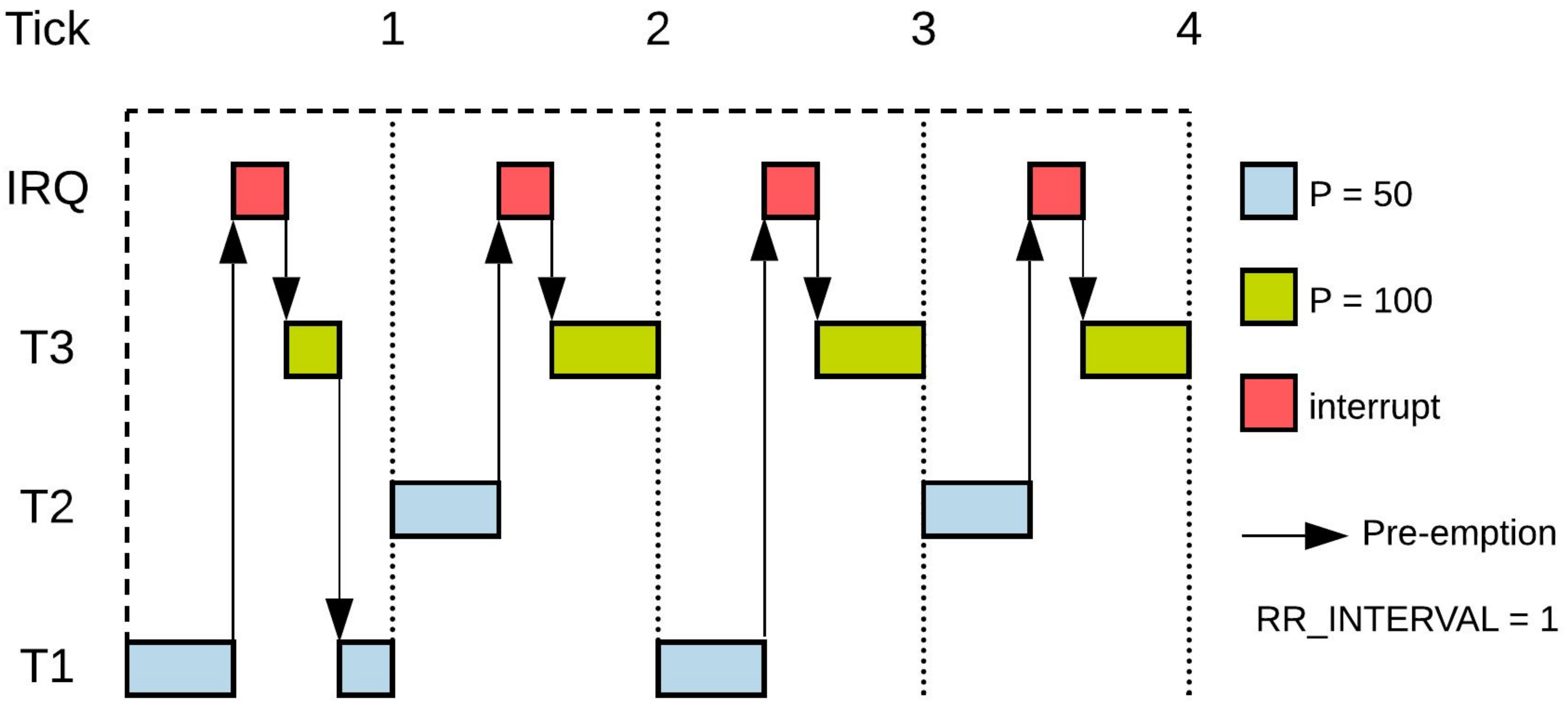
Can we do better?

- Only restore time slice on:
  - up_blocktask.
  - round-robin swap.

- On task suspend:
  - Subtract elapsed ticks from timeslice.
  - If preempted - save system time in tcb.

- On task resume - check if same tick:
  - If not during preemption tick - decrement timeslice.
  - Execute round-robin swap if timeslice is depleted.

Preemption Behaviour



A small compromise

- Solution requires updating all calls to sched_resume_scheduler in architecture code.

- Move round robin swap from task resume to task suspend.

Pros

- Tasks are guaranteed to execute at least RR_INTERVAL.
- The task that was preempted keeps its time slice if it is able to resume during the same tick.
- The task waiting next in line has to wait no more than RR_INTERVAL + 1 tick until it gets scheduled.

Round Robin and Tickless

- NuttX doesn't re-evaluate timer on context switch.
- Maximum timer period must always be RR_INTERVAL.
- RR_INTERVAL becomes a faux tick.
- RR preemption handling not possible.

Solution

- Drop the upper bound of the timer interval.
- Reassess alarm after context switches.

Obstacles

- Reassess triggers wdog timer processing.
- Ticks elapsed when setting up the context switch ➔ reassess updates the wrong task.

Pros

- CPU can sleep indefinitely when idle.
- Tasks that do not use RR policy not interrupted every RR_INTERVAL.
- Dynamic round robin time slicing.

Cons

- Reassessing the timer on context switch is a heavy operation.

- Implementation needs SCHED_TICKLESS_ALARM.

Future Improvements

- Move RR slicing to dedicate HW timer to mitigate the penalty of reassessing.

- Start RR slicing only when equal priority tasks are unblocked.

How do we measure scheduler performance?

- Power consumption ➔ -0.45% active duty cycle.
- Round robin swap rate ➔ +95% swap rate.
- UI responsiveness ➔ noticeable improvement.

Conclusion

- Preemptive strict priority scheduling meets real time processing requirements.
- Round robin policy increases fairness of same priority task scheduling.
- Tickless scheduling allows us to meet power requirements.

THANK YOU