The Priority-Band Architecture: a Partitioning Approach for the Definition of Avionics Reference Architectures

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Introduction

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- Which motivations promoted IMA
  - How IMA solved those problems?
- Can those problems be solved otherwise
  - Simpler
  - Leaner
  - Less rigid and yet equally effective
  - In a word: more efficiently

IMA goals

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- Support for logical partitions
  - Less hardware costs
  - Less harness
- Incremental update
  - Add/delete partitions with minimum impact
- Transparency of underlying technology

IMA drawbacks

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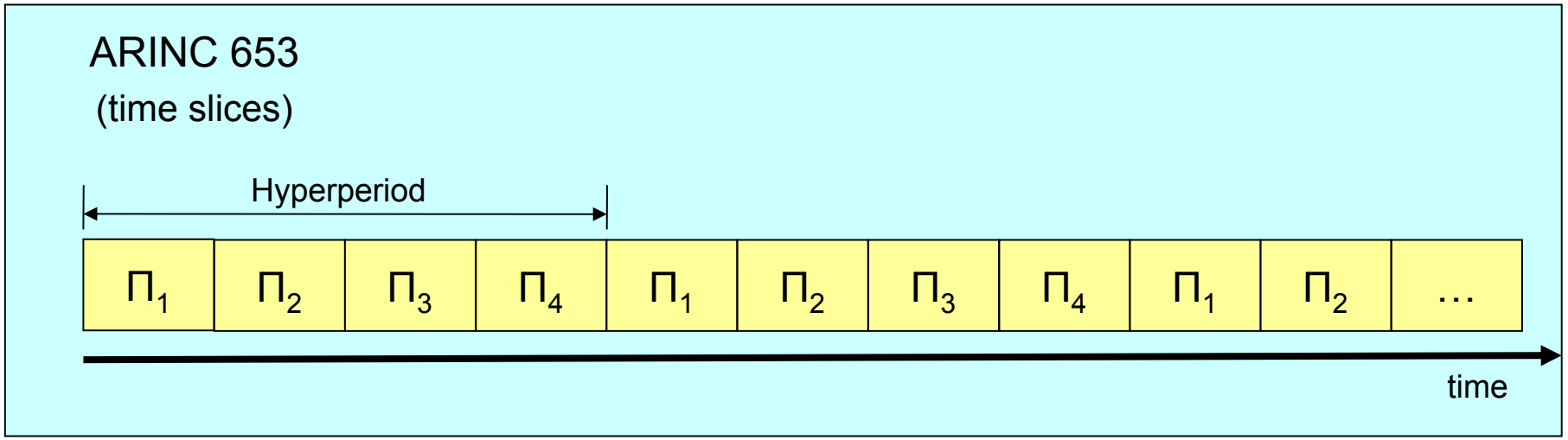
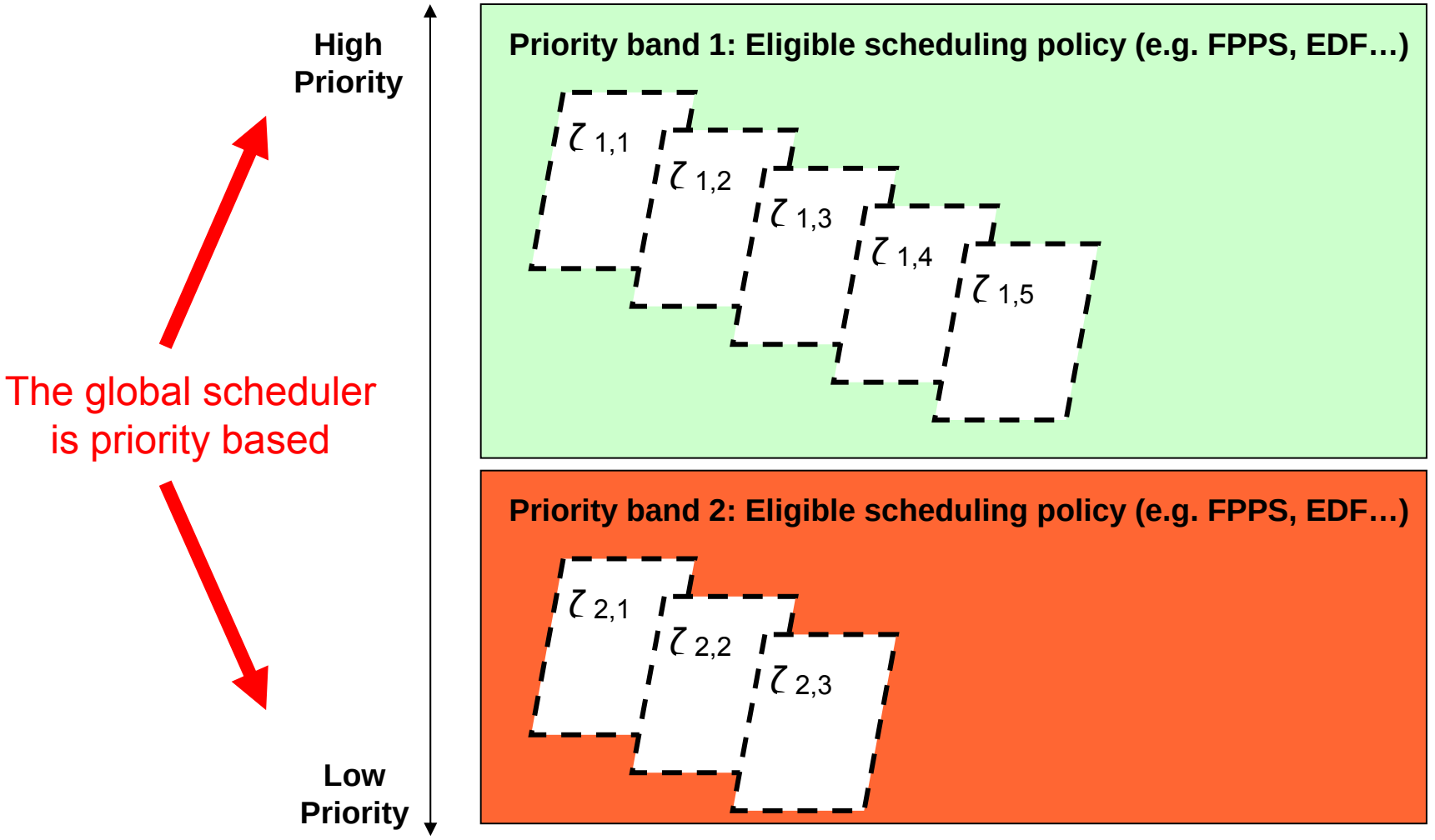
- Inflexible schedule
- Difficult to reconfigure
- Hard to accommodate sporadic tasks effectively
- Rigid and inefficient communication scheme



A novel approach



Priority bands details

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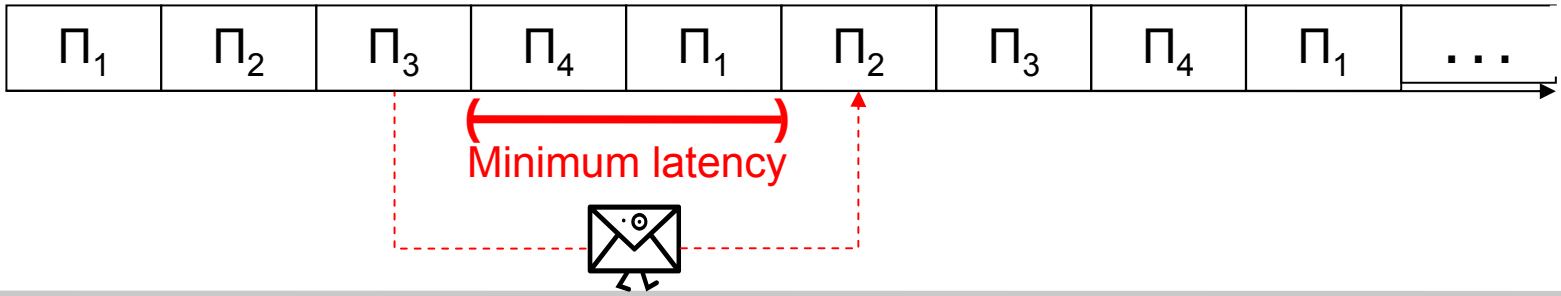
- Scheduling policies
  - Global scheduler: fixed priorities
  - Local schedulers: FPPS, FPNS, EDF, Round Robin
- Communications
  - Via shared resources (with synchronisation protocol)
    - » intra-partition and *inter-partition* communication
  - Priority-based
    - » immediate delivery, not time-triggered



Priority assignment (I)

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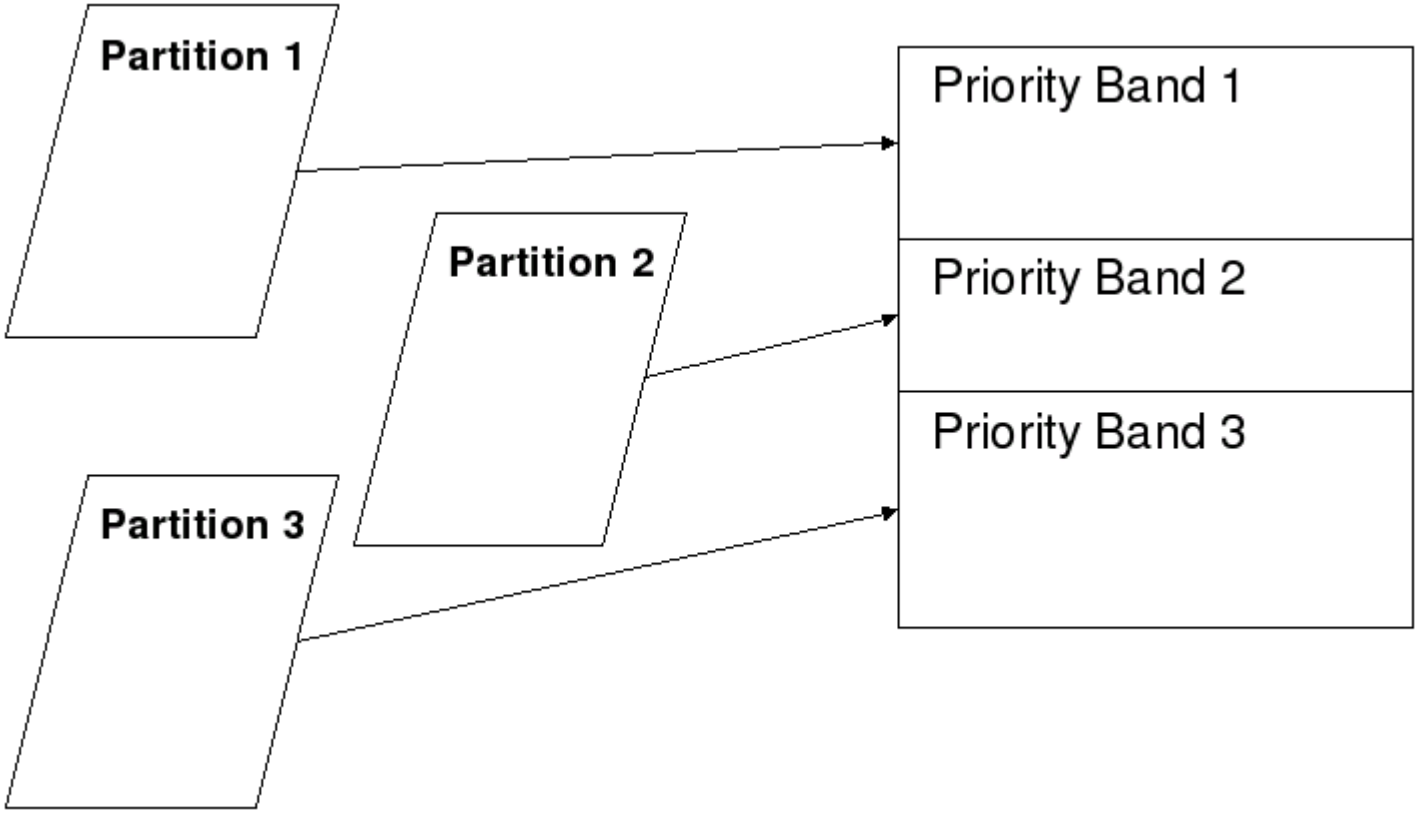
- Criticality based *vs.* Deadline monotonic



Priority assignment (II)

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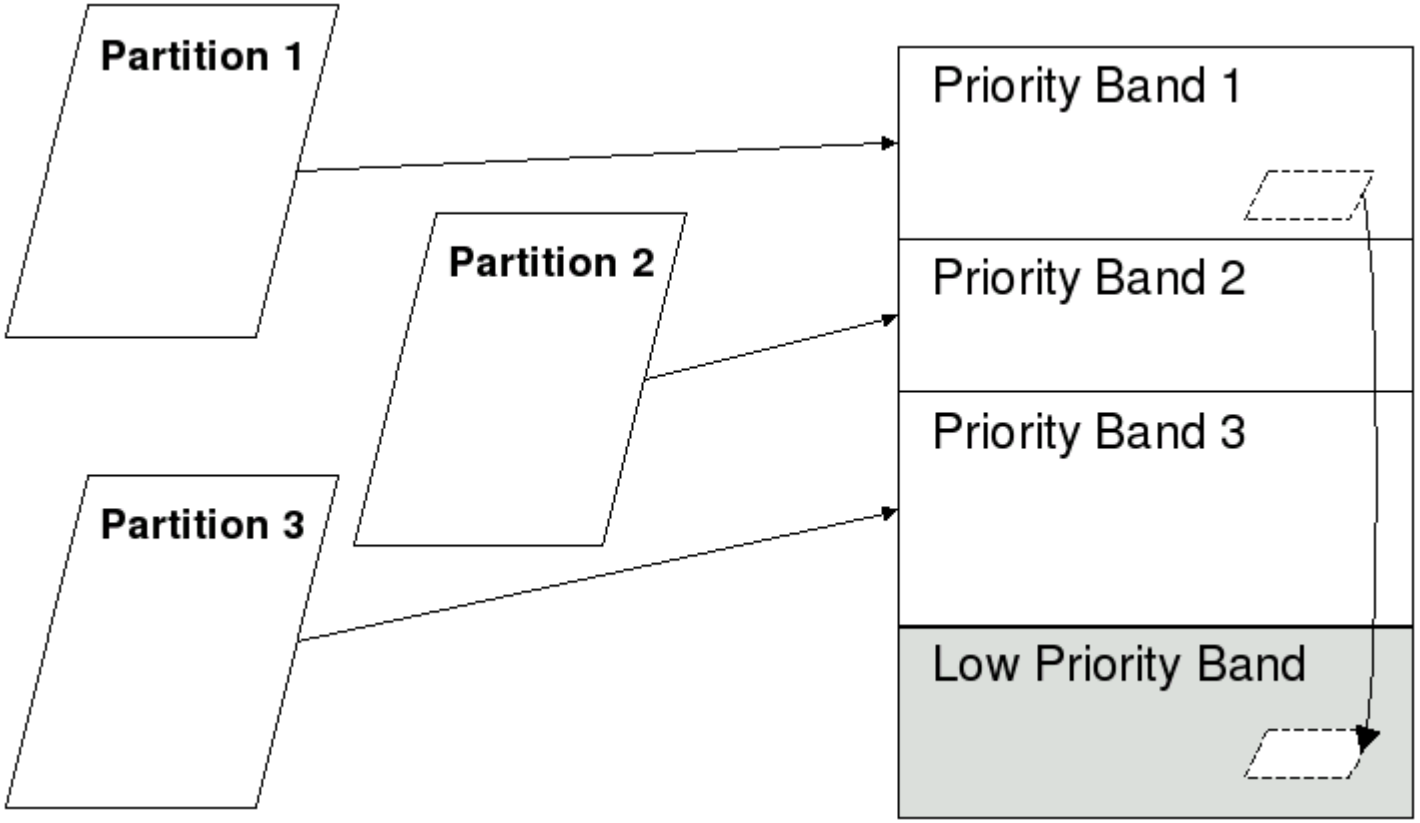
- Compromise solution



Temporal isolation

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- Temporal isolation obtained at three stages
  - **Design time**
    - » Priority assignment + static analysis
    - » Ravenscar Computational Model (RCM)
  - **Detection of anomalies at run time**
    - » WCET overrun detection
    - » Deadline surveillance
    - » Enforcement of minimum inter-arrival time
  - **Fault handling strategies**
    - » Second chance algorithm
    - » Mode change
    - » Controlled degradation

Spatial isolation

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- Design time
  - Static analysis techniques:
    - » e.g. SPARK tools
  - Linking model
- Run time
  - Needs HW-based memory protection mechanisms
  - Current space processors are too poor in this regard
    - » e.g. only two fence registers in LEON2

Current status (I)

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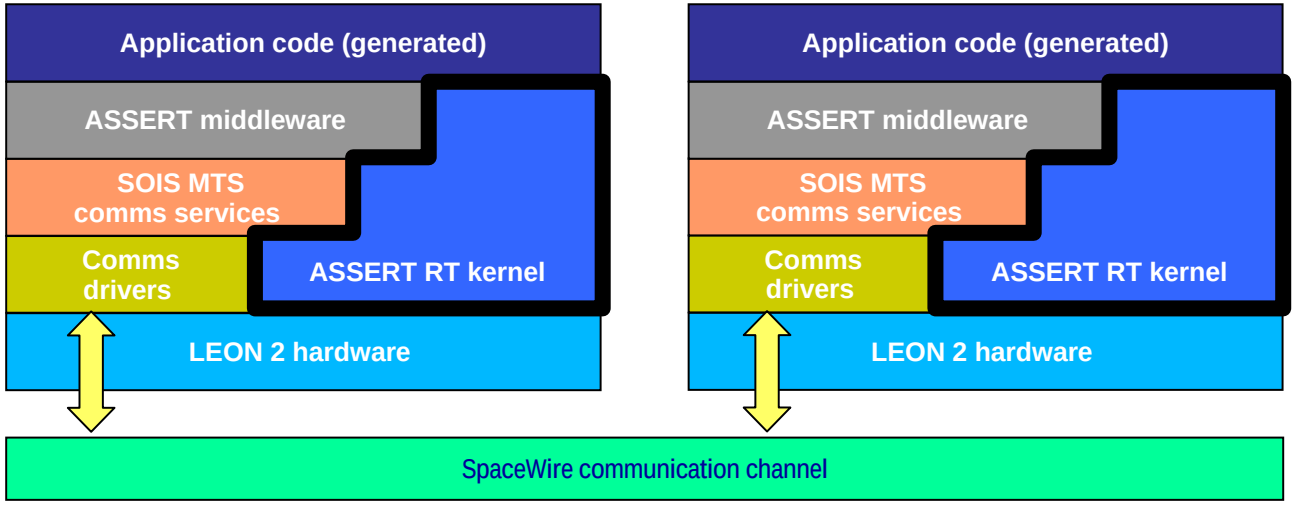
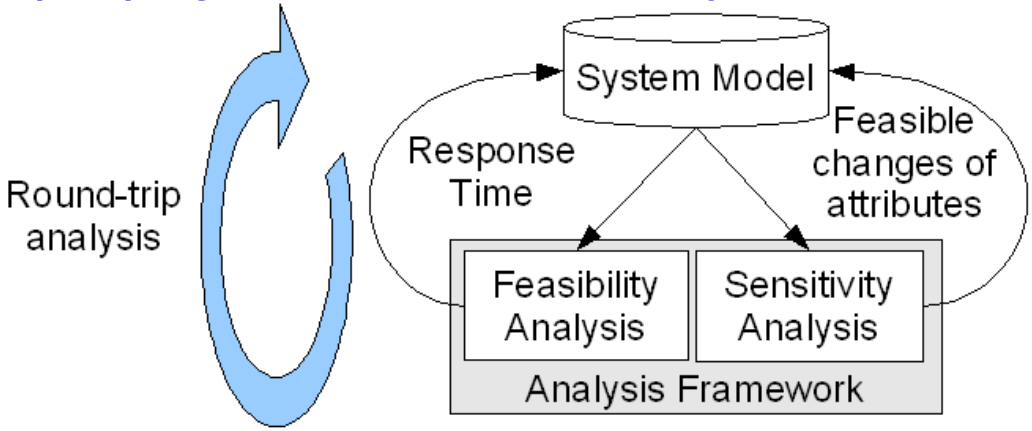
- GNATforLEON 1.4: a cross-compilation system which embeds a real-time kernel
  - Compliant with the Ravenscar profile
  - Provides support for temporal isolation



Current status (II)

- Model-based round-trip timing analysis
  - All relevant information directly gathered at model level
  - Performed on the architectural description of the system
    - » targeting the priority-band architecture
    - » tailored to the RCM
    - » full knowledge of all relevant platform-specific characteristics
  - Results propagated back to the system model



Conclusions

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- IMA
  - Good level of predicibility
  - Rigid and inflexible
    - » too much for the demands of today
- Priority-band Architecture
  - Simpler and elegant
  - Flexible
  - Improved efficiency
  - Warranted timeliness
    - » needs HW support to achieve effective space isolation