SAPM Design Example
Availability

30 January 2017

Availability

- Some systems we need to be there whenever they need to be used.
- These are usually called high availability systems.
- There can be different reasons for high availability:
  - 999 (or 911 or …) telephone system
  - Interplanetary spacecraft systems
  - Electricity supply grid
  - Large (and expensive) computer power supply

Availability

- From hardware there are two key measures:
  - *mtbf – mean time between failures*
  - *mttr – mean time to repair*
- The *availability* of a system is usually defined to be the probability it will be there when you ask it to work: *mtbf/(mtbf+mttr)*
- So there are two ways to make this number bigger (i.e. closer to 1): make the mean time between failures longer, make the system faster to repair

Faults, Errors, Failures

- A *fault* is something in the system (e.g. a broken wire, failed component, wrong bit of code, …) that can cause the system to move into an *error* state when the fault is activated, an error may then eventually cause an externally observable deviation from the intended operation and this is called a *failure.*
- Most high availability systems try to tolerate or mask faults by detecting erroneous conditions before they move into failure conditions.

Faults, Errors, Failures, Example

- A *fault* in a sorting routine means that under some circumstances it fails to sort an array.
- Under there conditions, the system might be assuming an array is sorted but it isn't. In this state there is an *error* in the system because things are not as they should be.
- If the system uses binary search to look for things in the array, sometimes an item will be in the array but will not be found – this might cause a visible *failure* of the system.

Generic Scenario

- **Source:** Internal or external sources important to differentiate because different measures are possible.
- **Stimulus:** Fault causes errors: *omission* (no result), *crash* (repeated omissions), *timing* (late, early), *response* (incorrect value).
- **Artifact:** Specifies what has to be available: process, channel, store, …
- **Environment:** what the mode of operation is: normal, degraded, startup, shutdown, …
- **Response:** how to respond to the stimulus
- **Response measure:** ***this will be some measure related to the availability or the "liveness" of the artifact***

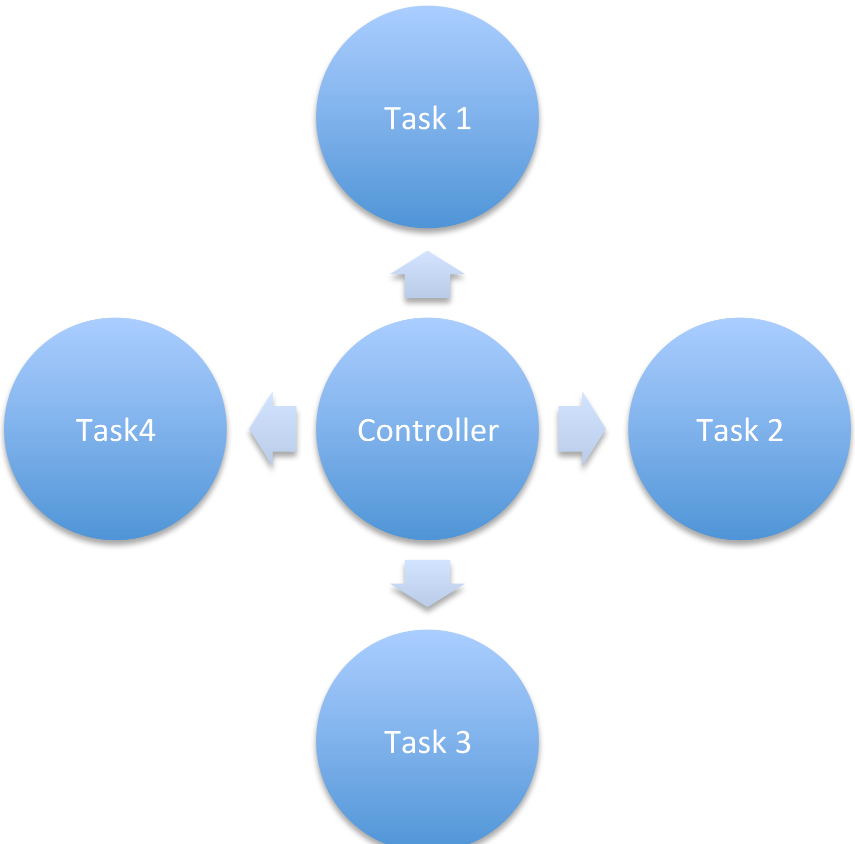
A Concrete Scenario

- In mission critical systems there is typically a schedule that activates a sequence of tasks in turn. These take longer or shorter times to complete and the whole set is carried out cyclically.
- What happens if there is a bug in a task and it never completes?
- So the concrete scenario might be as follows.

A Concrete Scenario

- Source: internal task process
- Stimulus: either omission or timing depending on how you look at it but the task does not respond as expected.
- Environment: normal operation
- Response: abandon task
- Response measure: system always responds within 200ms

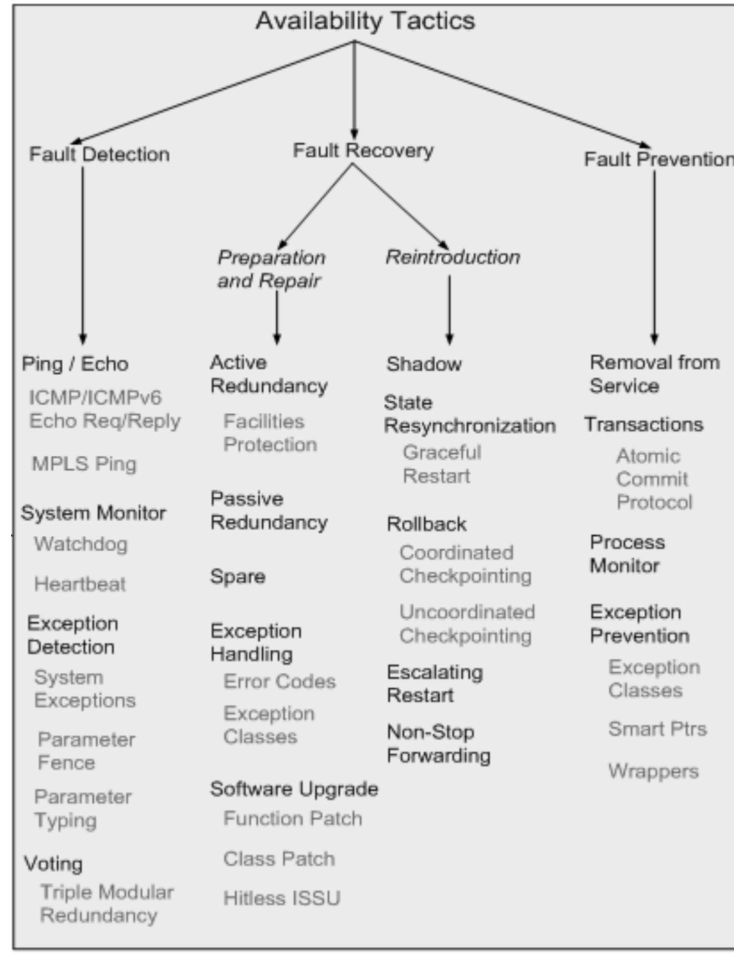
Simple Approach



- Cycles through each of the tasks.
- Passes control to the task
- Waits for control to pass back.
- What happens if a task fails?
- This architecture fails the scenario

Availability Tactics

- Our current architecture fails the scenario, why?
- Because we can't detect the error arising from the fault in a task.
- We look at the tactics to see how we might fix this.



What tactic might we take

- Use a watchdog: https://en.wikipedia.org/wiki/Watchdog_timer
- This would enable a correct response in the absence of a response from a task.
- Does it solve all the problems?
- What else might be necessary?
- Look at the tactic list

Architectural Design Decisions

- We can specialise our 7 categories to consider availability:
  1. Allocation of responsibilities
  2. Coordination model
  3. Data Model
  4. Management of resources
  5. Mapping among architectural elements
  6. Binding time decisions
  7. Choice of technology

Allocation of Responsibilities

- Determine what needs to be high availability (maybe not all functions).
- Responsibility for detecting error (and possible cause).
- Responsibility to log errors
- Responsible respond to a detected error
- Manage sources of events
- Decide on mode of operation
- Decide on how to repair faults
- …
- In our example we introduce the watchdog and give it responsibility for responding to error.

Coordination Model

- Are the error detection capabilities of the coordination model adequate to detect errors?
- Is the coordination model sufficient to ensure communication and coordination between error detection, log and response.?
- Will coordination work in the presence of error, degraded modes?
- If repair involve replacement of elements will the coordination model allow this?
- In our example the wakeup between watchdog and controller might be an addition to the coordination mechanism.

Data Model

- How do error conditions affect the data model?
- Does this mean we have to deal with some forms of corrupt data or incomplete operations?
- Perhaps the data model needs to be extended to include new operations to recover from failed earlier operations.
- For example, extending the model with checkpoint and rollback operations may be enough in some situations.

Management of Resources

- See what resources are essential to maintain operation in the presence of errors.
- Identify what resources are necessary for meaningful degraded modes.
- Work out if different scheduling changes the demand on critical resources.
- In our example if task 1 is in error because of a bad processor and task 4 is OK but not necessary for some degraded mode it may be best to switch task 1 and 4 and never schedule task 4 again to provide a degraded mode of operation.

Mapping between elements

- Determining what resources might be in error or might be affected by errors.
- Checking that remapping of elements is possible dynamically.
- How fast can elements be restarted or reinitiallised, can a process be moved to a new processor, …
- In our example it may be necessary to identify the watchdog as a new element and that a failing task may need to be mapped to a different processor.

Binding time decisions

- Look at binding time and see where this will allow flexibility.
- For example, if we can tolerate a 0.5s delay on a response but are currently using 0.1s as the time to signal an error then we might want to rebind and operate in a degraded mode.
- In our example, if the the taks code is burned into PROMS on the processors there is no chance to rebind task/processor.

Choice of technology

- Explore technologies that package useful functionality for availability.
- Use an established element if it is available.
- Use already established data on the availability characteristics of components.

Summary

- Availability is a good example QA.
- We looked at the definition.
- We saw how a scenario might capture a testable Availability requirement.
- We saw how an architecture might fail such a scenario.
- We say how tactics suggest ways to improve architectures.
- We also saw how the seven architecture design decisions map onto Availability as an example.