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## Fault Tolerant Concurrent Computing (cont'd)

- Have seen replication used for tasks to allow a program to recover from a fault causing a task to abruptly terminate.
- The same principle is also used at the system level to build fault tolerant systems.
- Critical systems are replicated, and system action is based on a majority vote of the replicated sub systems.
- This redundancy allows the system to successfully continue operating when several sub systems develop faults.

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## A Hierarchy of Failure Types

- Dead process
  - This is a special case of crashed process
  - Case when the crashed process crashes before it starts executing
- Crashed process
  - This is a special case of Byzantine process
  - Case when the Byzantine process crashes, and then keeps staying in that state for all future transitions

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## Types of Fault Tolerance Algorithms

- Robust algorithms
  - Correct processes should continue behaving thus, despite failures.
  - These algorithms tolerate/mask failures with replication & voting.
  - Never wait for all processes as processes could fail.
  - Usually deal with permanent faults.
  - Usually tolerate: N/2 benign, N/3 malign failures for N processes.
  - Study of robust algorithms centres around *decision* problems
- (Self-)Stabilizing algorithms
  - Processes could fail, but eventually become correct.
  - System can start in any state (possibly temporally faulty), but should eventually resume correct behaviour.
  - This eventually is known as the stabilization period

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## The Byzantine General Algorithm for One Traitorous General

- One general, the commander, decides on an initial decision. The remaining generals are called *lieutenants*.
- The algorithm for one traitorous general is:
  - 1. Commander sends his decision.
  - 2. Each lieutenant relays the commander's decision to every other lieutenant.
  - 3. Upon receiving both the direct message from the commander and the relayed messages from the other lieutenants, the lieutenant decides on an action my majority vote.

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