Railways and Parallel Computer Sysytems

Analogy

Railway systems can be thought of in terms of parallel computer systems. Both systems have protocols which have to be followed to avoid disaster. A collision between trains is a disaster in a railway system whereas an undetected corruption of data caused by conflicting processes constitutes a disaster in a computer system. We base our analogy on thinking of train journeys as threads of execution and trains as processes. The railway tracks can be thought of as processor allocation. A train must make its journey along a track. A train changing position on the track is conceptually equivalent to a process changing state. This raises some interesting issues when the topology of a railway network is considered.

multiple tracks Trains may behave independently on separate tracks in the same way that separate processes may execute independently on separate processors.

single track Trains share a single track. There must be a protocol for scheduling trains along a single track. In the same way processes executing on a single processor must have protocols so that there is no conflict when sharing resources.

junction A train is directed to a track at a junction under the control of the signalman. In the same way processes can be scheduled on processors by a scheduler of similar control program.

tunnel This is where the behaviour of the trains cannot be observed the only way to avoid disaster is to strictly adhere to the protocol for train in a tunnel. This is equivalent to remote procedure calls in computer systems (eg. Ada rendezvous) where the calling program cannot tell whether the execution is proceeding correctly it has to rely on the procedure following the protocol

correctly.

Protocols

A protocol is a collection of rules to control the operation of a system. For both railway and computer systems these protocols preserve safety. Every protocol has to have ways of communicating control to the subsystems that operate within the system. If the agents of the subsystems do not observe the communications or fail to follow the protocol exactly then disaster often results. Methods of communication for railway systems are

Tyer instrument A train takes an XY-tablet then relinquishes it at the end of the journey. This is the same as semaphores for parallel systems: a process claims a semaphore before a critical section and releases it at the end so that other processes may have that semaphore. A critical section can be thought of as equivalent to a single track where only one train is allowed to be on it simultaneously.

telegraph A telegraph is for communication between signal controls at junctions. In the same way message passing can be used in object-oriented programming to change the configuration of processes.

signals and dial indicators These forms of communication can be thought of in terms of communication via shared memory in a computer system. The communications can be observed by all agents within the system and changed by all agents. This can lead to different agents having different perceptions of the signal/indicator leading to a disaster!

Reasons for disaster

Disasters in both sorts of systems are for the same reasons

- Insufficient information. Information is kept at a minimum for efficiency but is often not enough to cover all requirents.
- Breakdown of protocol. Usually be agents not following the protocol correctly or making wrong observations.
- Incorrect protocol. Protocols have to be tested.