Systems Integration

Collaborative Systems

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Introduction

A Category of Systems

- Most systems discussed are product of centrally controlled development efforts
- Clear client, builder and user
- Many systems are not under central control
  - Conception, development, operation
- Canonical example: internet
- Electric power systems, multinational defense systems, ITS...
- Collaborative: assembled and operated through voluntary choice of participants
- Born collaborative / become collaborative (internet, GPS...)

Collaborative Systems

A System is a Collaborative System when its components

- Are complex enough to be regarded as systems
- The component systems also fulfill valid purposes alone
- Component systems are (partly) managed for their own purposes (rather than the purposes of the whole)

- Components are deliberately put together
- Classification is important: robust collaboration has to be planned for when direct control is impossible
- Own heuristics
- Importance of interfaces

Examples. The Internet

- Refering to the underlying communications infrastructure
- IP, TCP and UDP protocols
- IP may work on nearly any communications channel: easy to distribute, may not exploit features of a particular channel
- Data encapsulated in packets, independently forwarded through the net
- Routing decisions are local to each node
- Each node estimates the connection state of the system (no central control)
- Decentralized routing and decentralized development community
- Internet Engineering Task Force: issues standards that already have been developed
- Internet drafts
- Distributed operation, development and management

Examples. The Internet /2

- Relies on best effort operation
- Can not offer services requiring hard network-level guarantees
- Voice over IP: no quality of service guarantee
- Networks with more control offer richer services (ATM, Frame Relay...)
- Centralized and decentralized systems are vulnerable to destructive intentions
- Distributed systems are difficult to defend against coordinated distributed attacks. Centralized protocols have more knowledge of the problem and may resort to better policies under stress

Examples. ITS

- Improve road traffic conditions through ITs
- One concept: Fully coupled routing and control. Assumptions:
  - Large fraction of vehicles have and use a position reporting device
  - Large fraction of drivers enter their true destination when beginning trip
  - Large fraction of drivers follow the recommendations they get
- Vehicles are privately owned and operated
- Ensure the above conditions? Not collaborative: By mandate plus enforcement
- Architectural choices for collaboration
- Market-based approach: Paying subscribers. If recommendations are valuable they pay
- This approach may not be able to implement some management policies available to a centralized system

Examples. Joint Air Defense Systems

- Joint effort of several nations
- Data fusion (ground radars, airborne radars, human observers...) to obtain a picture of air space
- Allocate weapon systems to engage selected targets
- Conflicts: each protects their own assets
- Solvable with centralized control. But...???
- Accept independence but try to forge an effective collaborative system
- Communication is very important
- Social side: shared training or educational background, shared responsibility, shared cultural background...

Analogies for Collaborative Systems

Urban planner

- Helps structuring communities
- The architect's client builds the result
- The urban planner's client does not build the city: guides others who will build parts of it
- Spiral or evolutionary development (not a waterfall)
  - Plan is updated as actual conditions change

Business Relationships

- Business with semi-independent divisions
- Merged companies: have to become a collaborative system to jointly achieve more
- Franchise giving the franchisees significant independence

Collaborative System Heuristics

Stable Intermediate Forms

- *Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not*
- Idea of self-support during construction (in the physical and non-physical sense: economic, politic self-support)
- Stability: intermediate forms should be self-supporting
- Technical: fulfills useful purposes
- Economical: generates revenues to maintain operation. It should be an economic interest to keep operating rather than disengaging
- In collaborative systems we cannot assume that all participants will continue to collaborate. Plan fall-back modes
  - Air defense systems: down to gunner working with his binoculars
  - Internet: nodes attach and detach at will

Collaborative System Heuristics /2

The Triage

- Select components and set priorities and allocate resources according to:
- *Let the dying die. Ignore those who will recover on their own. And treat only those who would die without help*
- Decide what not to control. Overcontrol fails due to lack of authority. Undercontrol produces no real *system*
- The MPEG group chose to standardize the information needed to *de*compress a video stream. Compression will be handled by competing firms.

Collaborative System Heuristics /3

Leverage at the Interfaces

- *The greatest leverage in system architecting is at the interfaces. The greatest dangers are also at the interfaces*
- When components are highly independent, the architecture is the interfaces
- Architect tries to create emergent capability
- IETF does not standardize physical interconnections nor applications beyond network protocol layer
- Attention is directed to different elements than in conventional systems
  - Life-cycle cost is irrelevant to architect

Collaborative System Heuristics /4

Ensuring Cooperation

- *If a system requires voluntary collaboration, the mechanism and incentives for that collaboration must be designed in*
- Cost-benefit ratio of collaboration should be better than that of independence
  - Internet: cost low, benefit high
- Alternative: produce situation where each one's well-being is (partially) dependent on the other's well-being
- Franchise metaphor
- *Consider a collaborative system as a franchise. Always ask why the franchisees choose to join, and then choose to remain as members*

Variations on the Collaborative Theme

Closed Collaborative Systems

- Central authority exists but power is expressed through collective action
- Participants decide and act to take the system in a new direction
- System is centrally long-term managed to continue to fulfill its purposes

Open Collaborative Systems

- Central management has no coercive power to run the system
- Internet with IETF: works out standards but has no power to enforce them
- Participants choose to implement them without proprietary variations (almost)

Variations on the Collaborative Theme /2

Virtual Collaborative Systems

- No central management and no agreement upon purposes
- World Wide Web
  - No control. Only standards on resource naming, navigation and document structure.
  - Web sites choose to obey standards or not
  - Standards emerge from market success
  - Purposes change depending on users
- National economies
  - Attempts to architect this system
  - Distributed mechanisms

Classifications

Open-Source Software: a Collaborative System

- Often thought as synonym to GNU/Linux
- Success of Linux: development model for software and non-software
  - Designs and initial implementations should be carried out by gifted individuals or very small teams
  - Software products should be released to the maximum possible audience as quickly as possible
  - Users should be encouraged to become testers and even co-developers by providing them source code
  - Code review and debugging can be arbitrarily parallelized, at least if source code is distributed to reviewers and testers
- Loses the ability to make money distributing software
- Quality of open-source software: broad reviewer base / Darwinian selection

Classifications /2

Military Services: an Open Collaborative System

- Thought as a closed system
- Builder and operator thinks he has more control over operation and purpose than he really has

Usenet and WWW: Virtual Collaborative Systems

- Purpose and structure are not under direct control
- New purposes and new behavior arises
- Originally intended for research information exchange. Now have diverse purposes, some undesired and even illegal

Standards and Collaborative Systems

- Standard: framework for establishing collaborative systems
- The standard creates the environment within which implementations can coexist and compete
  - Telephone standards
  - APIs
- Standards organizations: ISO, ANSI, UNE... Democratic, reflecting consensus
- Standards in operating systems: proprietary or open
- *Standards are network goods, and must be treated as such*
- Standards are useful if others use them
- IETF gives away standards for free. Others do not
- IETF standards are accompanied by free source code implementing them
- Real collaboration is important. It is not indicated by voting but by doing action that costs something