LIVING FLIGHT SOFTWARE

A 40 YEAR INTERPLANETARY VOYAGE

David E. Smyth
Principal Flight Systems Software Engineer
THERE WERE PROGRAMMERS BEFORE ME
I MAY BE OLD, BUT I AM NOT THAT OLD
THE FIRST MICROPROCESSORS

1972: PPS-4
128KIPS
4-BIT WORD
12-BIT (4K) ADDRESS SPACE
12-BIT STACK
1 GP REGISTER
1 MATH REGISTER
1 INTERRUPT
ASSEMBLY + MACHINE CODE
PROGRAMMERS IN 1972 WERE PROFESSIONALS
HAND PICKED FROM THE ENGINEERING RANKS
PROGRAMMING TOOLS

DIRECT MANIPULATION, SYMBOLIC, HIGH SPEED NETWORK,
CODE REVIEWS, FULL COLOR USER INTERFACE, WITH OBVIOUS RELIABILITY

DATE 1972  CLIENT SR-71 DIGITAL FLIGHT CONTROL
STACK OVERFLOW? WIKIPEDIA?

BUT PATTERNS DID EMERGE
The Pattern

- Identify the data
- Decide types (4-bits for each BCD digit, fixed point)
- Identify algorithms (get from the mathematician)
- What data is operated on by what algorithm
  - Data locality forced by limited addressing - data needs to be within 128 bytes of instruction
- Select instruction that takes data from source, operates on it, and then stores in destination.
- Repeat
OPERATING SYSTEMS AND PROGRAMMING LANGUAGES
CP/M, RDOS, FLOPPIES, BASIC, AND MORE ASSEMBLER

DATE
LATE 1970’S

CLIENT
NASA, NATO, SONY
The Real-Time Pattern

- Set priority based on time to deadline
  - Closer the deadline, higher the priority

- Corollary: high priority must have short run time
WHO KNOWS, THIS JUST MIGHT WORK

1979 SEVENTH EDITION, ALSO 2.7 BSD
SPACE SHUTTLE
1981
Wait for the next hand...
T-9mins
Lessons

- Even when you are not allowed to refactor, if refactoring allows you to meet deadlines and pass tests, then seek forgiveness ...

- Tests must be comprehensive, automated, and fully repeatable. Failing to repeat is a fail.
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Objects

- Research at Siemens 1990-1992 comparing multiple projects found C a better object-oriented language than C++ or Obj-C
- Object programming in C uses simple, common rules: see
Agents and the Law

- Simple model for safe, high performance multi-threading
- Law of Demeter
  - Each method operates only on the arguments and the receiving object’s state.
- Similar to REST
- DSL, implemented with Tcl, used to autogenerate messaging infrastructure
AI on Pathfinder

- Had to be done on the sly…
- Based on Subsumption by Rod Brooks, and coordination concepts by Maja Mataric.
- Start at the bottom, and work up
- As schedule allows, abstraction (apparent intelligence) increases. Base behaviors remain, but are subsumed and coordinated by “higher level” behaviors.
- 300+ commands in command dictionary, but only about 20 used for mission.
Telemetry

- Maximize the value of the telemetry
- Don’t send low value telemetry
  - On-change, on-delta, ...
  - Logger with Debug, Info, Warn, Fatal ...
- Ack/nack to delete or re-xmit
Organization

- Everybody knows the prioritized success criteria
  - Use to make tactical decisions: i.e., When is this meeting over?
- Everybody works to prioritized requirements
  - Concentrate on what is needed first
- Focus on flight artifacts
  - Documentation minimized — refer to document from another mission, don’t write new ones
  - Each engineer does systems engineering — who are your interfaces, make sure you understand their needs, work those issues. No intermediaries.
- Tony Spear was project manager, mentor.
  - Tony also mentored CEO of Millennium Space Systems.
PROJECT:
SPRIT AND OPPORTUNITY

MPF V2

DATE:
2004

CLIENT:
MARS
CURIOSITY

HOW HARD CAN WE MAKE IT ON OURSELVES?

DATE 2012

CLIENT MARS