Analyzing the Core Flight Software (CFS) with SAVE

Dharmalingam Ganesan (dganesan@fc-md.umd.edu)
Dr. Mikael Lindvall (mlindvall@fc-md.umd.edu)
David McComas (David.C.McComas@nasa.gov)

Dave's Flight Software Group

Fraunhofer – a short intro

- Fraunhofer Center Maryland
  - Applied research and technology transfer
  - Not for profit
  - Affiliated with the University of Maryland
    - CEO also full professor in Computer Science, UMD
  - Sister institute in Kaiserslautern, Germany
- Business model
  - Conducts applied research in software architecture, verification & validation, process improvement and measurement
  - Contract research for industry and government clients
    - Clients/partners:
      - Bosch, Biofortis, DOD, FDA, JHU, JHU/APL, NASA…..
  - Receives NSF grants in software engineering

Context of this Collaboration

- Fraunhofer CESE received a NASA IV&V SARP grant on software architecture evaluation
- SAVE technology is partly funded by the SARP grant
- One component is outreach to NASA projects
  - Apply to various kinds of software systems
  - Get feedback, improvement suggestions
    - Technology AND Project
  - Share, publish results

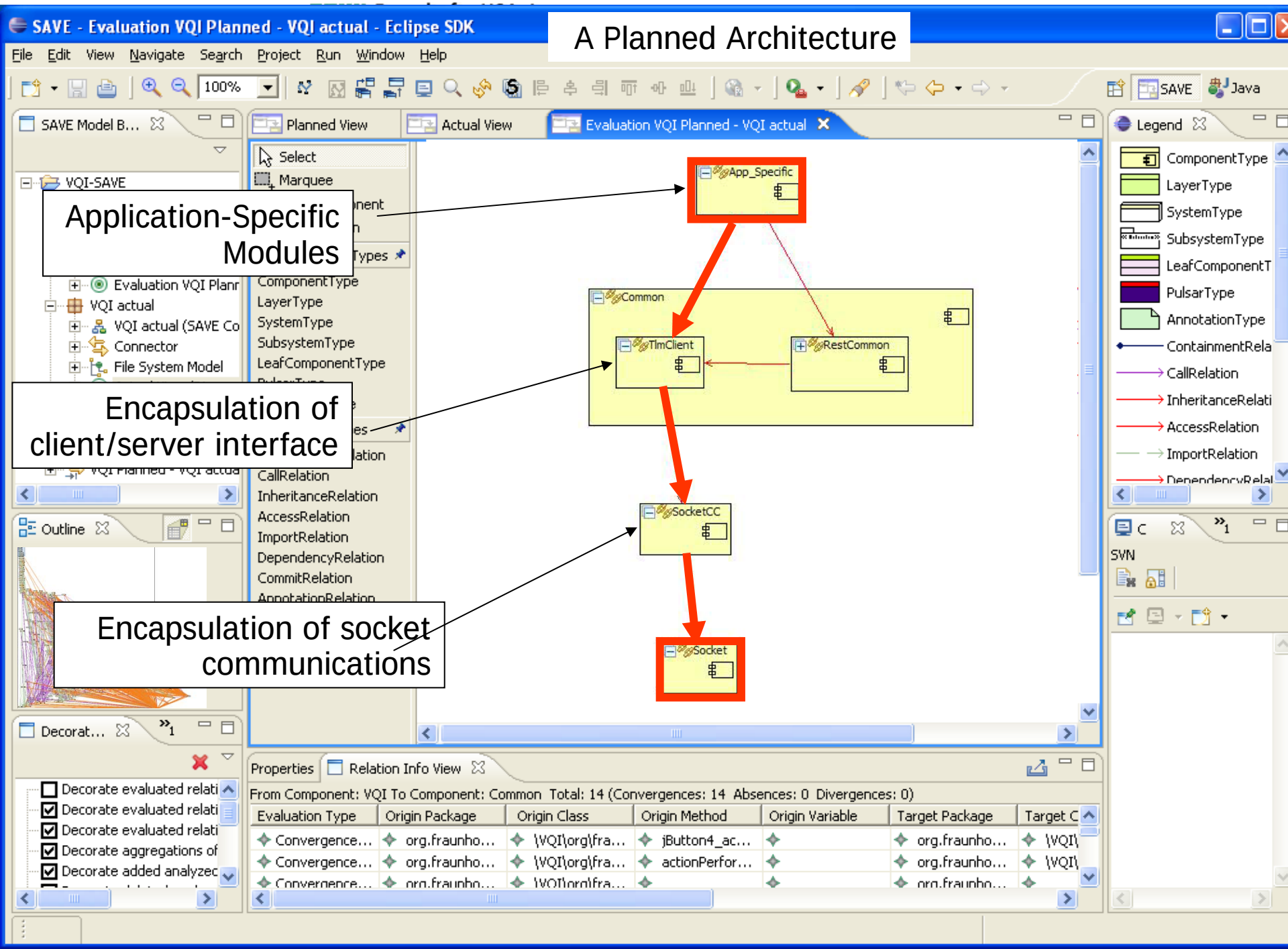
CFS – Core Flight Software?

- CFS is project-independent flight software (FSW) that provides a runtime environment and a set of FSW applications
- Applications that comply with CFS API's can be reused for multiple missions
- CFS is designed for reuse using sound engineering principles, such as Layering, Modularity, Product Line
- Challenge: How to check whether CFS implementation and Applications follow the intended design rules to ensure "long-term" reuse

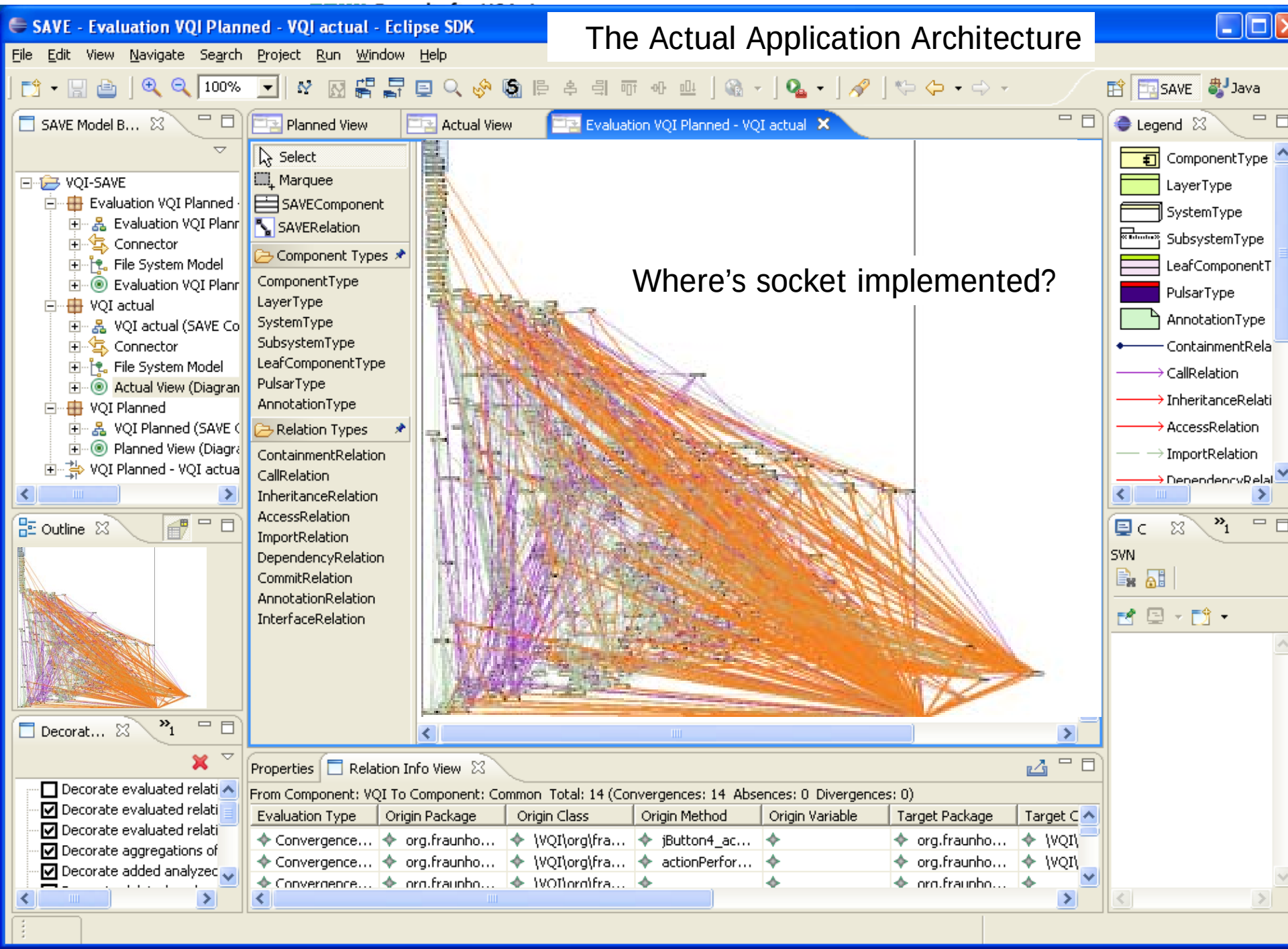
The SAVE Tool

- Sample problem: How do you “understand” and “check” a larger software system?
  - Starting by looking at each line of code might not be feasible
- SAVE can automatically extract architectural views from the implementation (source code)
- SAVE can check the compliance of source code with the planned architecture (if any)
- Set of Eclipse plug-ins
- Supports C/C++, Java, Delphi, Simulink etc

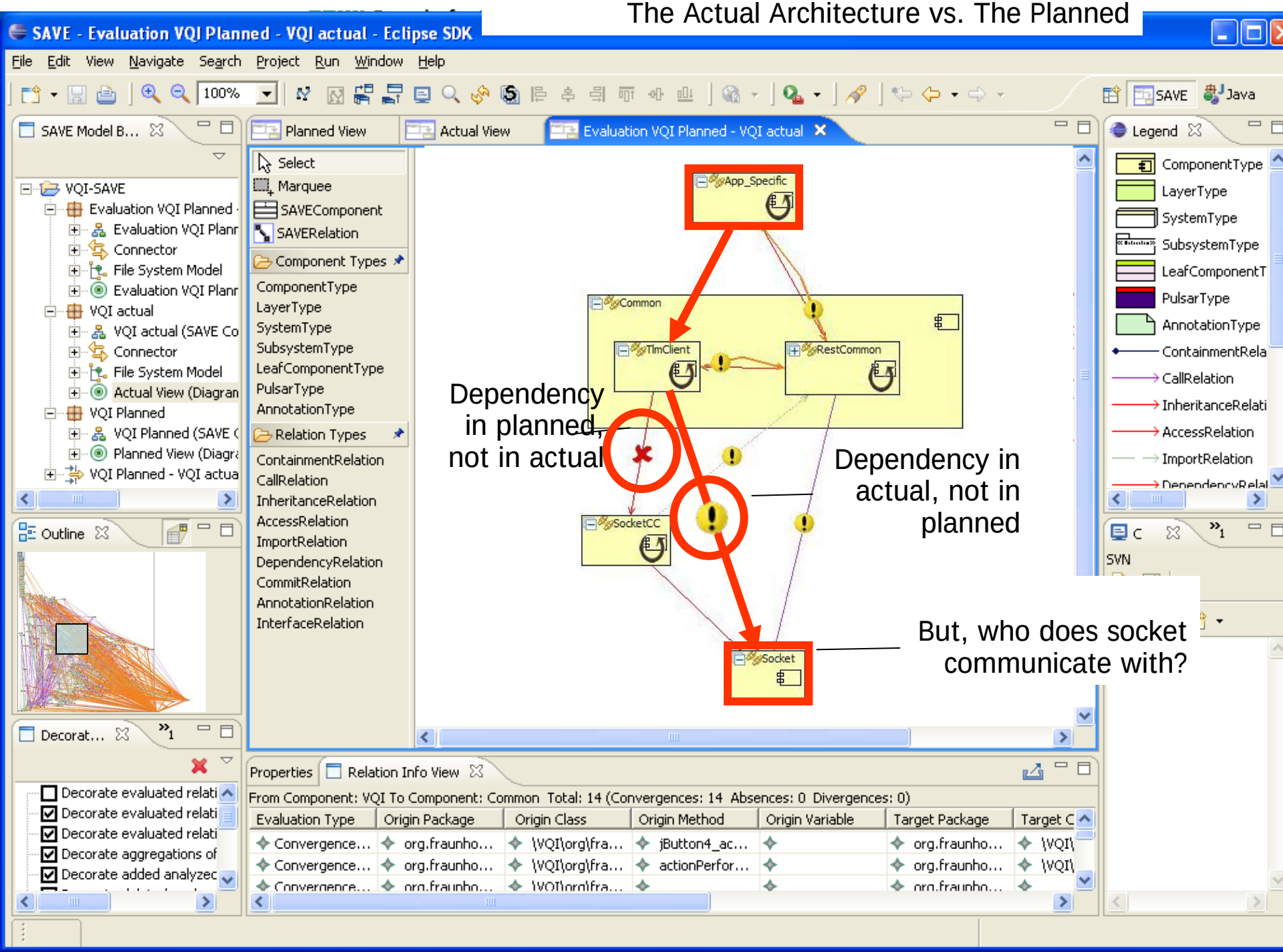
A Planned Architecture



The Actual Application Architecture



The Actual Architecture vs. The Planned



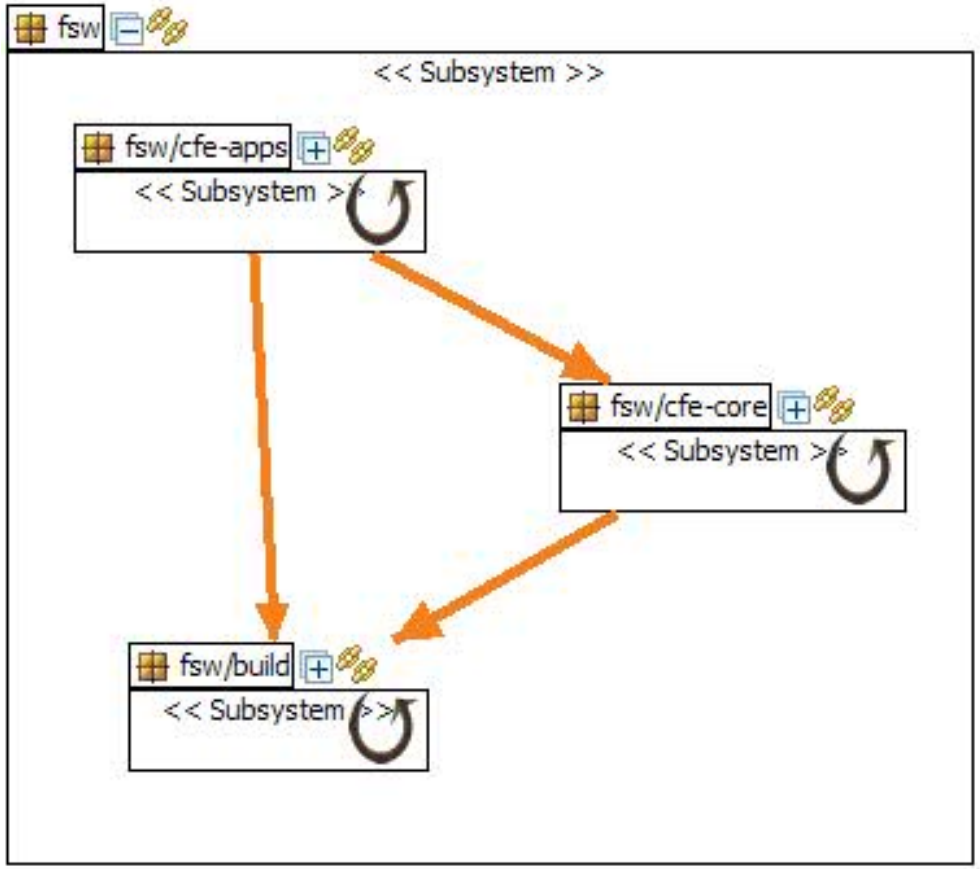
Applying SAVE to CFS

-A few example analyses

Goals

- Check if CFS implementation is consistent with design goals
- Evaluate and propose improvements of the CFS structure
- Check if all CFS applications have uniform look-and-feel
- Analyze variability potential of the CFS

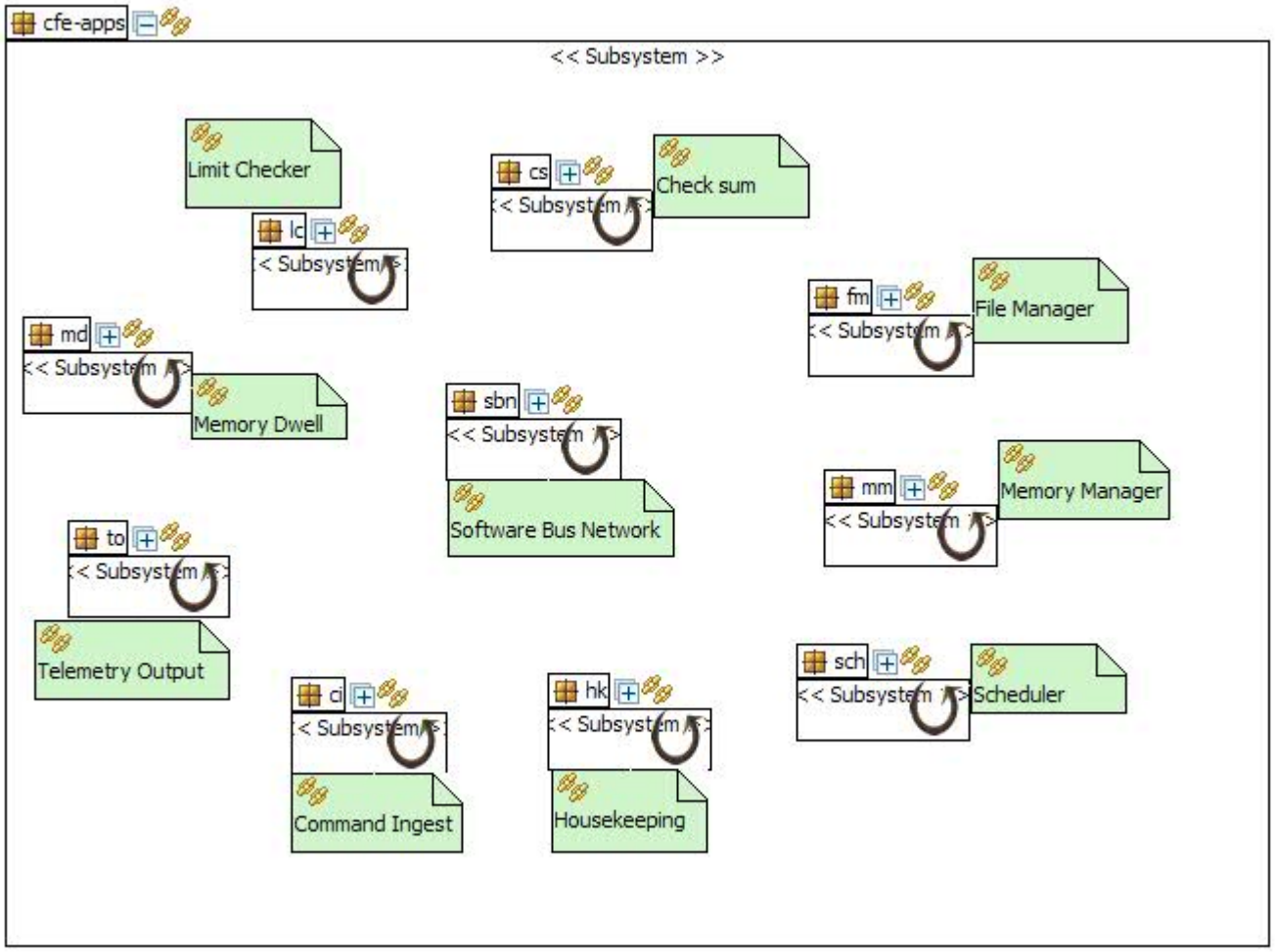
Implemented High-level View of CFS



This implemented view is consistent with the design guideline:

Cfe-app should use *Cfe-core*, but not vice-versa

Implemented View of Cfe-Apps

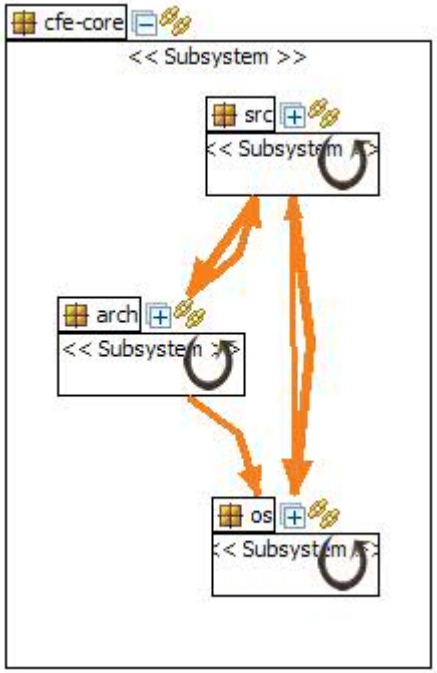


Design Rule

No two applications are allowed to interact directly, and should instead use a bus to communicate

Yes. The code does follow the design rule

Implemented View of CFE Core



Design Rule

Avoid cyclic dependencies (Basic design principle)

The dependency from os to src is avoidable by moving the “common_types.h” from src to os.

Implemented View of Cfe-core Services

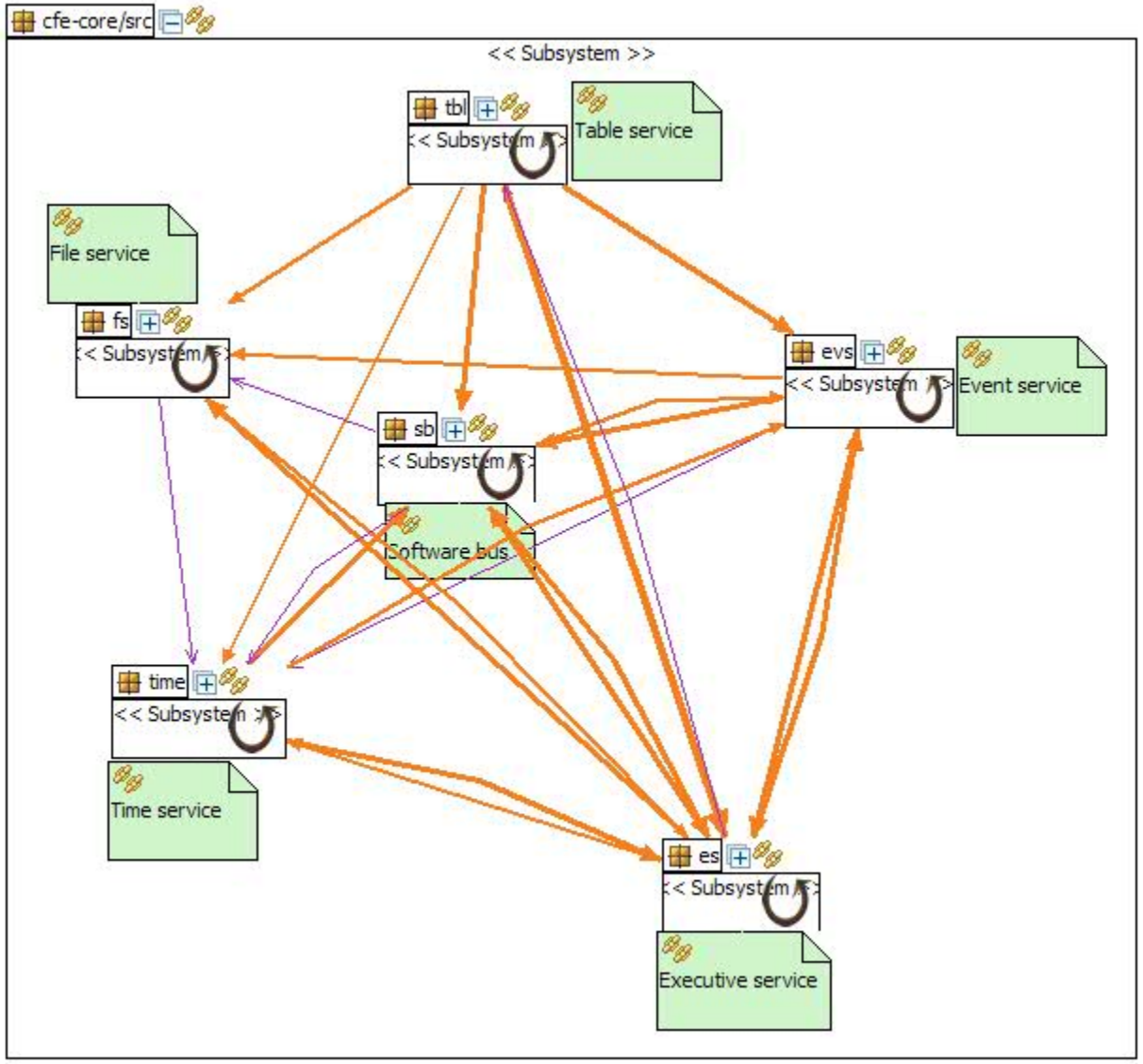
Comments

These dependencies are valid, and necessary according to the CFS team.

The SAVE analysis helped to Validate the planned design

Question:

Is it possible to deliver Cfe Without table service?

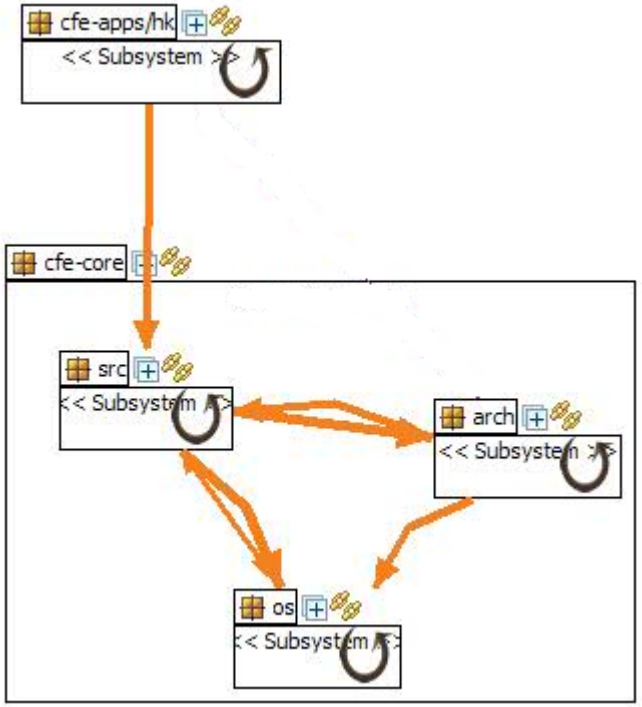


Analysis of CFS Applications

- SAVE was used to analyze dependencies from CFS apps to cfe core services

- The following applications were analyzed:
  1. HK – Housekeeping
  2. MD – Memory Dwell
  3. MM – Memory Manager
  4. CS – Checksum
  5. FM – File Manager
  6. LC – Limit Checker

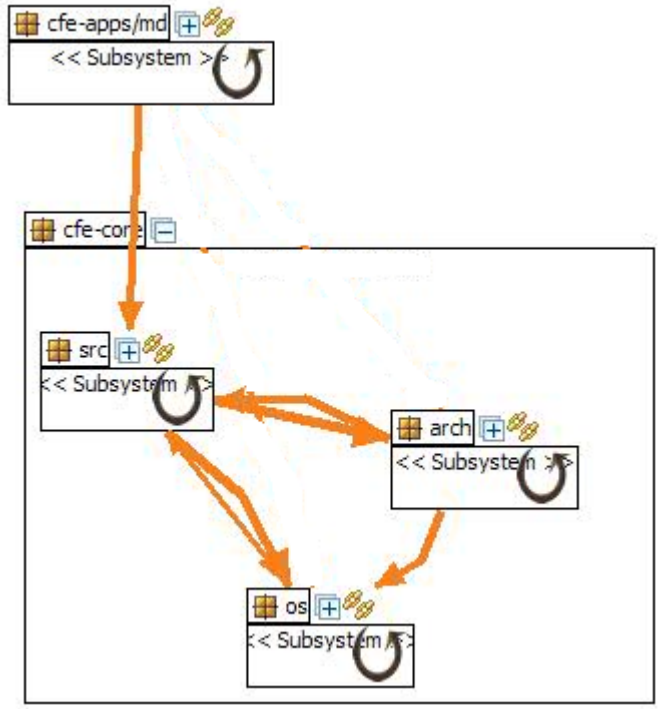
Analysis of Applications to CFE Dependencies

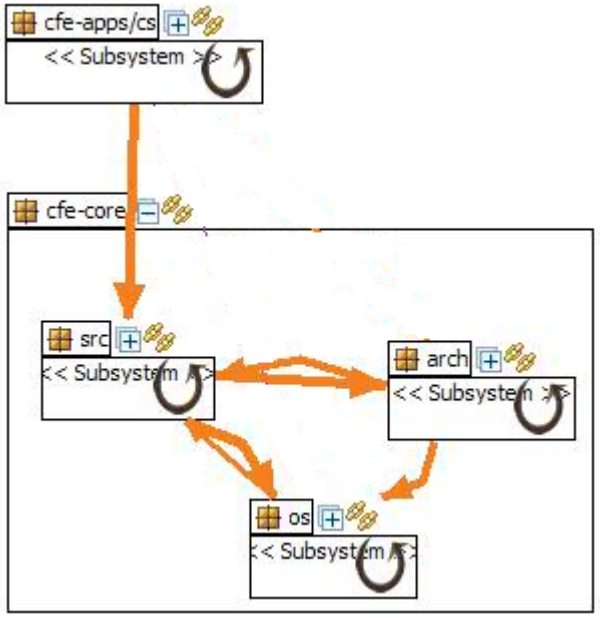


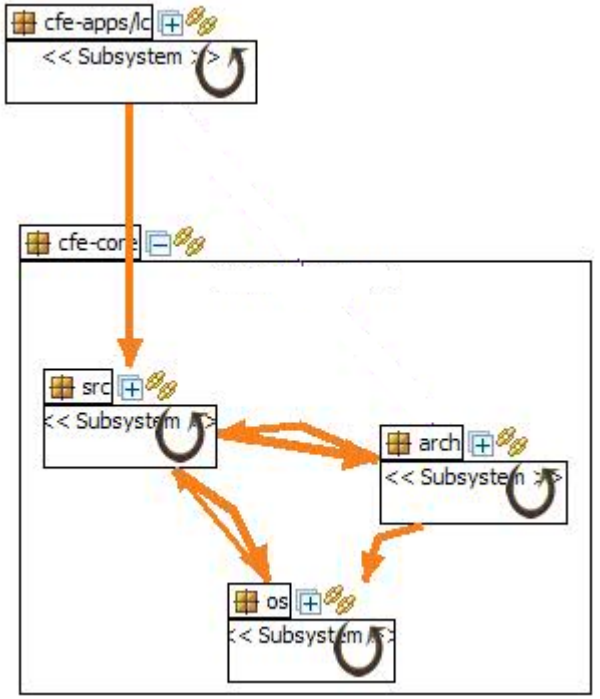
CFS Design Rule:
Applications should not directly use arch and os

Origin Folder	Origin Component	Origin Routine	Target Folder	Target Component	Target Routine	Relation Type
cfe-apps/hk/fsw/src	hk_utils.c	HK_TearDownOl...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL
cfe-apps/hk/fsw/src	hk_utils.c	HK_SendCombin...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL
cfe-apps/hk/fsw/src	hk_utils.c	HK_ProcessInco...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL
cfe-apps/hk/fsw/src	hk_utils.c	HK_CheckStatus...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL
cfe-apps/hk/fsw/src	hk_utils.c	HK_ProcessNew...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL
cfe-apps/hk/fsw/src	hk_app.c	HK_VerifyCmdLe...	cfe-core/src/evs	cfe_evs.c	CFE_EVS_SendE...	CALL

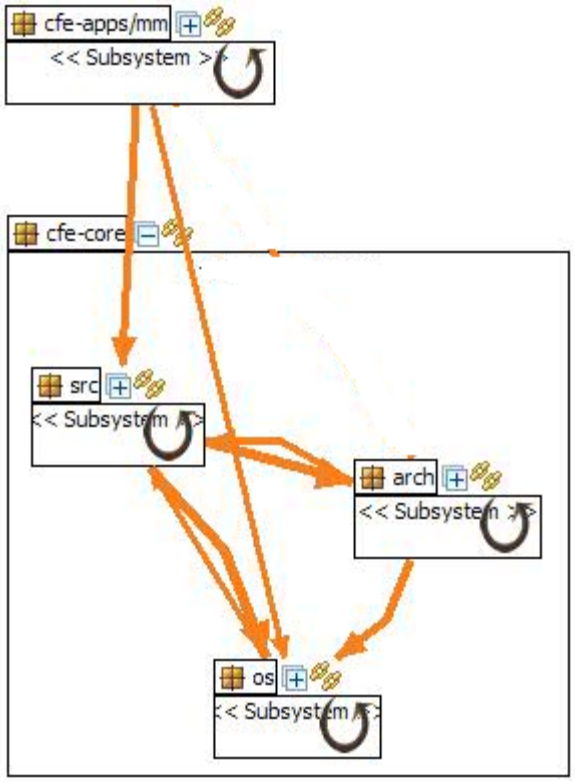
Analysis of Applications to CFE Dependencies ...







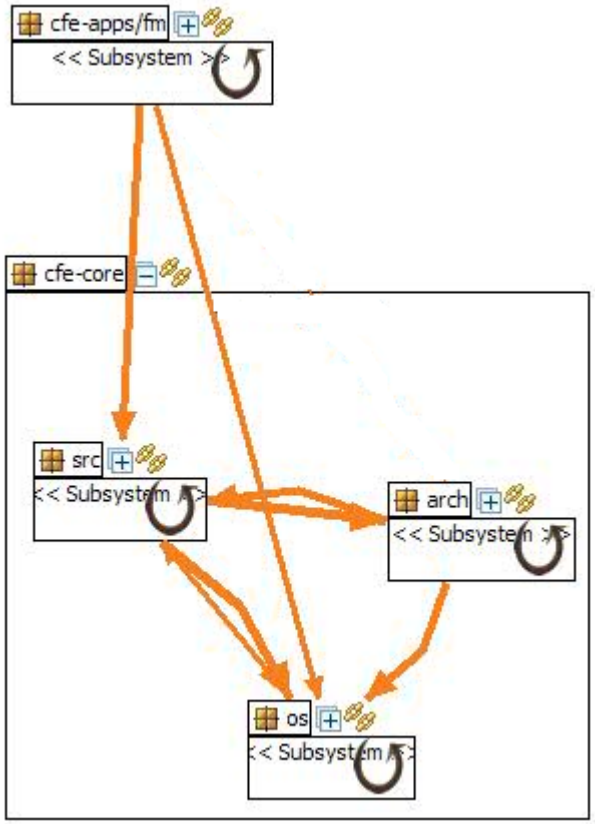
Analysis of MM to CFE Dependencies



Problem:
mm_load.h directly uses os by directly including "osapi-os-filesys.h"

Solution:
Just remove that include statement. mm_load.h already includes cfe.h which includes "osapi.."

Analysis of FM to CFE Dependencies



Problem:
fm_cmds.c directly uses os by directly including "osapi-os-filesys.h"

Solution:
Just remove that include statement. fm_cmds.h already includes cfe.h which includes "osapi.."

Analysis of Applications to CFE Dependencies

	Executive Service (ES)	Event Service (EVS)	Software Bus (SB)	Table Service (Tbl)	File Service (FS)	Time Service
House Keeping (HK)	X	X	X	X		
Memory Dwell (MD)	X	X	X	X		
Memory Manager (MM)	X	X	X		X	
Check Sum (CS)	X	X	X	X		
File Manager (FM)	X	X	X	X	X	X
Limit Checker (LC)	X	X	X	X		X

- All applications are directly using:
  - Executive service to initialize
  - Event service for communication
  - Software bus to send/receive messages

- However, we still need all cfe services because Es, Evs, and SB depend on Table, File and Time Service

- More analysis is needed to validate and introduce appropriate Variability management technique

Conclusion and Future Work

- CFS implementation does follow its planned design
  - There are some deviations from the design which needs further analysis
- By SAVE analysis, the distance between design and code can be significantly reduced!
- Future Work:
  - Dynamic dependencies among applications will be extracted using runtime execution and analysis of logs
  - Ordering of messages among applications will have to be analyzed
  - Timing information will be collected to check and resolve bottlenecks due to the interaction through message bus