
Usability-Supporting Architectural Patterns

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USAP Tutorial ICSE 2004 - page 1

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Schedule

Time	Topic
9:00-9:15	Instructor introduction & tutorial objectives
9:15-9:30	What is Software Architecture & What is Usability? ? Basic Concepts of each
9:30-9:45	How software architecture and usability techniques fit into a software development activities
9:45-10:30	Separation based architectural patterns and their motivation ? J2EE-MVC ? PAC Why separation is inadequate for interactive systems
10:30-11:00	BREAK

USAP Tutorial ICSE 2004 - page 2

Schedule

Time	Topic
11:00-11:30	Usability-Supporting Architectural Patterns (USAP) ? Introduction to the parts of a USAP ? Example of a USAP - problem statement, forces, and general responsibilities
11:30-12: 30	Small Group Exercise: ? Applying the problem statement and forces to a real-world problem brought by the members of the breakout group (one group per instructor) ? Report-out to the entire group
12:30-2:00	LUNCH

USAP Tutorial ICSE 2004 - page 3

Schedule

Time	Topic
2:00-2:30	Sample solution for example problem.
2:30-3:30	Small Group Exercise: ? Apply sample solution to real-world problem introduced in prior break out ? Report-out to entire group
3:30-4:00	BREAK
4:00-5:15	A second USAP: ?Example with Observing System State USAP
5:15-5:30	Tutorial wrap-up

USAP Tutorial ICSE 2004 - page 4

Introductions

Who are we?

- Len Bass
- Bonnie John
- Natalia Juristo
- Maribel Sanchez-Segura

Who are you?

What do you want to get out of this tutorial?

USAP Tutorial ICSE 2004 - page 5

Bonnie John is an engineer (B. Engr., The Cooper Union, 1977; M. Engr. Stanford, 1978) and cognitive psychologist (M.S. Carnegie Mellon, 1984; Ph. D. Carnegie Mellon, 1988) who has worked both in industry (Bell Laboratories, 1977-1983) and academe (Carnegie Mellon University, 1988-present). She is an Associate Professor in the Human-Computer Interaction Institute and the Director of the Masters Program in HCI. Her research includes human performance modeling, usability evaluation methods, and the relationship between usability and software architecture. She consults for many industrial and government organizations.

Len Bass is an expert in software architecture & architecture design methods. Author of six books including two textbooks on software architecture & UI development, Len consults on large-scale software projects in his role as Senior MTS on the Architecture Trade-off Analysis Initiative at the Software Engineering Institute. His research area is the achievement of various software quality attributes through software architecture and he is the developer of software architecture analysis and design methods. Len is also the past chair of the International Federation of Information Processing Working Group on User Interface Engineering.

Dr. Natalia Juristo is a professor of software engineering with the Computing School at the Universidad Politecnica de Madrid. From 1992 until 2002 she was the Director of the MSc in Software Engineering. Dr. Juristo has a B.S. and a Ph.D. in Computing. She was fellow of the European Centre for Nuclear Research (CERN) in Switzerland in 1988, and staff of the European Space Agency (ESA) in Italy in 1989 and 1990. During 1992 she was a resident affiliate of the Software Engineering Institute at Carnegie Mellon University. She was program chair for SEKE97 and general chair for SEKE01 and SNPD02. Prof. Juristo has been the keynote speaker for CSEET03. She has been the guest editor of special issues in several journals, including the Journal of Software and Systems, Data and Knowledge Engineering and the International Journal of Software Engineering and Knowledge Engineering. Dr. Juristo has been a member of several editorial boards, including IEEE Software and the Journal of Empirical Software Engineering. She is a senior member of IEEE.

Maribel Sanchez-Segura has been a faculty member of the Computer Science Department in the Carlos III Technical University of Madrid since 1998. Her research interests include software engineering, interactive systems, and usability. Maribel holds a B.S. in Computer Science, a M.S. in Software Engineering and a Ph.D. in Computer Science from the Technical University of Madrid.

Tutorial objectives: The scene

The usability analyses or user test data are in; the development team is poised to respond. The software had been carefully modularized so that modifications to the UI would be fast and easy. When the usability problems are presented, someone around the table exclaims, "Oh, no, we can't change THAT!"



USAP Tutorial ICSE 2004 - page 6

Tutorial objectives: The scene

The usability analyses or user test data are in; the development team is poised to respond. The software had been carefully modularized so that modifications to the UI would be fast and easy. When the usability problems are presented, someone around the table exclaims, "Oh, no, we can't change THAT!"

The requested modification, feature, functionality, reaches too far in to the architecture of the system to allow economically viable and timely changes to be made.

- **Even when the functionality is right,**
- **Even when the UI is separated from that functionality,**
- **Architectural decisions made early in development can preclude the implementation of a usable system.**

USAP Tutorial ICSE 2004 - page 7

Tutorial objectives:

- Understand basic principles of software architecture for interactive systems and its relationship to the usability of that system
- Be able to evaluate whether common usability scenarios will arise in the systems you are developing and what implications these usability scenarios have for software architecture design
- Understand patterns of software architecture that facilitate usability, and recognize architectural decisions that preclude usability of the end-product, so that you can effectively bring usability considerations into early architectural design.

USAP Tutorial ICSE 2004 - page 8

What is Software Architecture?

Enumeration of all major software components

Each component has enumeration of responsibilities

Interaction among components specified

- Control and data flow
- Sequencing information
- Protocols of interaction
- Allocation to hardware

There are many ways to document this information
(Clements, et. al. 2003)

USAP Tutorial ICSE 2004 - page 9

Clements, P., Bachmann, F., Bass, L., Garlan, D., Ivers, J., Little, R., Nord, R., & Stafford J., (2003) Documenting Software Architectures: Views and Beyond, Addison Wesley.

Purposes of Software Architecture

Communication among stakeholders

- An educational purpose
- A managerial purpose

Artifact for analysis

- Embeds early design decisions

Set of blueprints for implementation

What does usability mean?

As many definitions as there are authors!

What's important depends on context of use

Some commonly-seen aspects

- efficiency of use
- time to learn to use efficiently
- support for exploration and problem-solving
- user satisfaction (e.g., trust, pleasure, acceptance by discretionary users)

Our concern is which of these can be influenced by architectural decisions

USAP Tutorial ICSE 2004 - page 11

A usability benefits hierarchy

Increases individual user effectiveness

- Expedites routine performance
 - Accelerates error-free portion of routine performance
 - Reduces the impact of routine user errors (slips)
- Improves non-routine performance
 - Supports problem-solving
 - Facilitates learning
- Reduces the impact of user errors caused by lack of knowledge (mistakes)
 - Prevents mistakes
 - Accommodates mistakes

Reduces the impact of system errors

- Prevents system errors
- Tolerates system errors

Increases user confidence and comfort

USAP Tutorial ICSE 2004 - page 12

Activities in software development

System Formulation
Requirements
Architecture Design
Detailed Design
Implementation
System Test and Deployment

USAP Tutorial ICSE 2004 - page 13

Activities in software development + HCI techniques

System Formulation - HCI techniques: Interviewing, questionnaires, Contextual Inquiry
Requirements - HCI techniques: Interviewing, questionnaires, Contextual Inquiry
Architecture Design - HCI techniques: What we'll learn today
Detailed Design - HCI techniques: Heuristic Evaluation, Cognitive Walkthrough, GOMS, PICTIVE, Rapid prototyping+user testing, etc.
Implementation - HCI techniques: UI Toolkits
System Test and Deployment - HCI techniques: User testing in the field, Log analysis, etc.

USAP Tutorial ICSE 2004 - page 14

Detailed Design - Common Practice for Interactive Systems

System Formulation - HCI techniques: Interviewing, questionnaires, Contextual Inquiry
Requirements - HCI techniques: Interviewing, questionnaires, Contextual Inquiry
Architecture Design - HCI techniques: What we'll learn today
Detailed Design - HCI techniques: Heuristic Evaluation, Cognitive Walkthrough, GOMS, PICTIVE, Rapid prototyping+user testing, etc.
Implementation - HCI techniques: UI Toolkits
System Test and Deployment - HCI techniques: Think-aloud Usability Testing, Log analysis, etc.

USAP Tutorial ICSE 2004 - page 15

Detailed Design - Common Practice for Interactive Systems

The HCI techniques supporting detailed design of the user interface are all based on iterative design

- i.e., design, test (analyze or measure), change, and re-test.

Once software has been designed, iteration implies change.

Software engineers plan for change through isolating section to be changed (separation).

In detailed design, the items to be separated are those relating to presentation, input, possibly dialog.

USAP Tutorial ICSE 2004 - page 16

Separation Based Architectural Patterns for Usability

Presentation-Abstraction-Control (PAC)

- Developed in 1980s by group at the University of Grenoble
- Reaction to shortcomings of Smalltalk Model-View-Controller (MVC)

J2EE Model-View-Controller (J2EE MVC)

- Developed by Sun to support J2EE
- Adaptation of Smalltalk MVC to web environment

Separation based patterns are commonly used in practice and have proven quite successful

USAP Tutorial ICSE 2004 - page 17

PAC is documented in:

Buschmann, F., Meuneir, R, Rohnert, H., Sommerlad, P. and Stal, M., (1996) Pattern-Oriented Software Architecture, A System of Patterns, Chichester, Eng: John Wiley and Sons.

J2EE-MVC is documented at <http://java.sun.com/blueprints/patterns/MVC-detailed.html>

Presentation-Abstraction-Control (PAC)

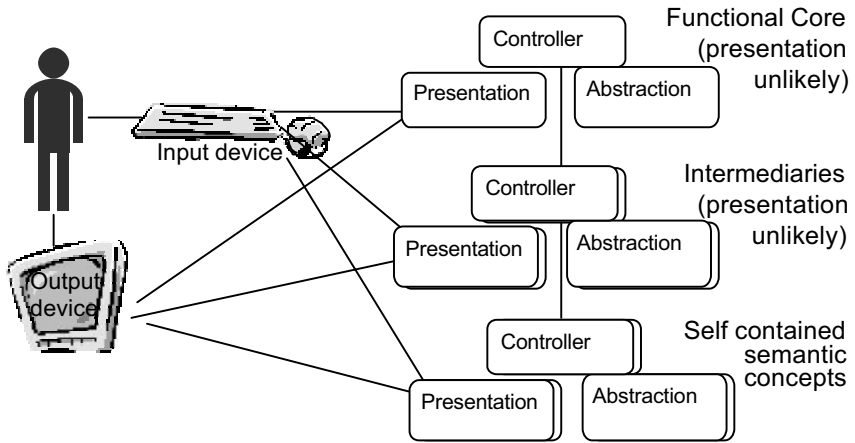
Hierarchical series of agents

- Top-level agent provides functional core
- Bottom level agents are self contained semantic concepts such as spread sheets or forms.
- Intermediate level agents act as intermediaries between top level and bottom level agents and determines which bottom level agents are active.

Each agent has three portions:

- Presentation - Input/output manager (unlikely to occur except in bottom level)
- Abstraction - Application functionality
- Control - Mediator between Presentation & Abstraction and communicator to controls at other levels

Presentation-Abstraction-Control (PAC)



J2EE Model-View-Controller

Object-oriented

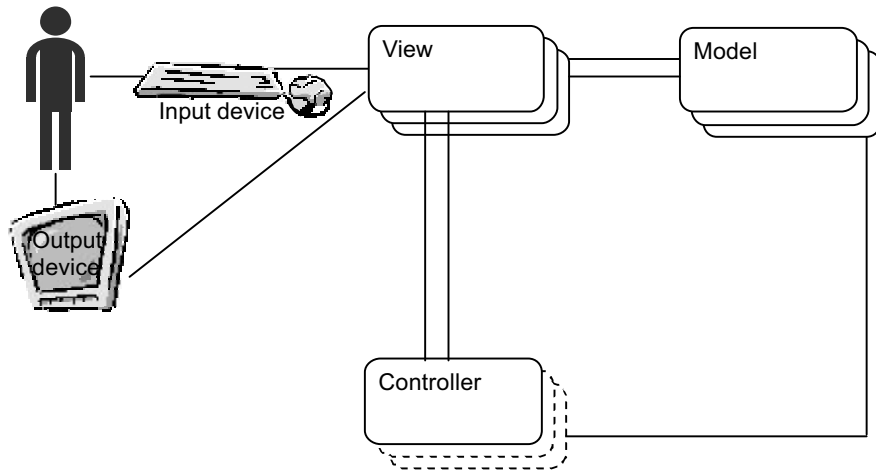
- Model - Application state and functionality
- View - Renders models, sends user gestures to Controller
- Controller - Updates model, selects view, defines application behavior

Differences from PAC

- Separates management of the input from the output
- View updates itself directly from the model
- PAC hierarchical concept managed outside of J2EE-MVC

USAP Tutorial ICSE 2004 - page 20

J2EE Model-View-Controller



USAP Tutorial ICSE 2004 - page 21

Software architectural patterns

PAC and J2EE MVC are “software architectural patterns”
(Buschmann, et. al., 1996)

Independent of application

Provides some indication of assignment of responsibilities to components

Much left unspecified:

- Allocation to processes
- Synchronous/asynchronous communication
- Decomposition of components
- Class structure
- Other responsibilities of components
- Exceptions

Sufficient to give overall guidance for design approach

USAP Tutorial ICSE 2004 - page 22

Buschmann, F., Meuneir, R, Rohnert, H., Sommerlad, P. and Stal, M.,
(1996) *Pattern-Oriented Software Architecture, A System of Patterns*,
Chichester, Eng: John Wiley and Sons.

Software architectural patterns - 2

Patterns community has a variety of styles and levels of detail for writing about patterns

- Buschmann, et. al., (1996) provide prose descriptions, architecture-level diagrams, and sample code.
- Gamma, et. al., (1995) provide prose descriptions, class diagrams, and code samples
- Hillside Group advocates mainly prose and emphasizes pattern languages above individual patterns

USAP Tutorial ICSE 2004 - page 23

Buschmann, F., Meuneir, R, Rohnert, H., Sommerlad, P. and Stal, M., (1996) *Pattern-Oriented Software Architecture, A System of Patterns*, Chichester, Eng: John Wiley and Sons.

Gamma, E., Helm, R., Johnson, R., Vlissides, J. (1995). *Design Patterns*. Boston, Massachusetts: Addison-Wesley.

Information about the Hillside Group and patterns and pattern languages can be found at <http://www.hillside.net/>

Why separation-based architectural patterns are not sufficient for interactive systems

Remember iterative design?

USAP Tutorial ICSE 2004 - page 24

How does J2EE MVC support iterative design?

Change color of font

- Modify only View
 - View contains all display logic; font changes only require modifying the display

Change order of dialogs

- Modify only Controller
 - Controller defines the presentation flow, so changing dialog order involves modifying the controller logic

What happens to other usability changes?

Add the ability to cancel a long-running command

- Requires modification of all three modules
 - View – must have cancel button or other means for user to specify cancel
 - Controller – logic to respond to the View's menu selection and execute the appropriate Model function
 - Model – free allocated resources, etc.

Shortcomings of separation patterns for solving the “We can’t change THAT!” problem

With respect to adding the ability to cancel

- Involved all components
- Not much localization
- If requirement for cancel discovered late, then will require extensive modification to the architecture.

USAP Tutorial ICSE 2004 - page 27

**After the break, we'll start
addressing these shortcomings
with usability-supporting
architectural patterns**

USAP Tutorial ICSE 2004 - page 28

Beyond separation-based architectural patterns

Our goal is to provide software designers and usability specialist tools to recognize and prevent common usability problems that are not supported by separation.

We are doing this by:

- Identifying those aspects of usability that are “architecturally sensitive” and embodying them in small scenarios
- Providing a way to reason about the forces acting on architecture design in these scenarios
- Providing checklist of important software responsibilities and possible architecture patterns to satisfy these scenarios

USAP Tutorial ICSE 2004 - page 29

What does architecturally-sensitive mean?

A scenario is architecturally-sensitive if it is difficult to add the scenario to a system after the architecture has been designed.

Solution may:

- Insure that multiple components interact in particular ways
- Insure that related information and actions can be found in a single component and easily changed

Separation patterns intended to localize changes to presentation. Therefore,

- Changing color of font – NOT architecturally-sensitive
- Adding cancellation – IS architecturally-sensitive

USAP Tutorial ICSE 2004 - page 30

An architecturally-sensitive scenario: Canceling commands

The user issues a command then changes his or her mind, wanting to stop the operation and return the software to its pre-operation state. It doesn't matter why the user wants to stop; he or she could have made a mistake, the system could be unresponsive, or the environment could have changed.

USAP Tutorial ICSE 2004 - page 31

What other architecturally-sensitive scenarios can you think of?

USAP Tutorial ICSE 2004 - page 32

Here are some others we have thought of

Aggregating Data	Reusing Information
Aggregating Commands	Retrieving Forgotten Passwords
Alert	Shortcuts
Canceling Commands	Status indication
Checking for Correctness	Supporting Comprehensive Searching
Evaluating the System	Supporting International Use (Different Languages)
Form/Field Validation	Supporting Multiple Activities
History Logging	Supporting Personalization (User Profile)
Maintaining Device Independence (Different Access Methods)	Supporting Undo
Maintaining Compatibility with Other Systems	Supporting Visualization
Making Views Accessible	Tour
Modifying Interfaces	Using Applications Concurrently (Multi-Tasking)
Navigating Within a Single View	Verifying Resources
Observing System State	Wizard
Operating Consistently Across Views	Workflow model
Providing Good Help (Context-Sensitive Help)	Working at the User's Pace
Predicting Task Duration	Working in an Unfamiliar Context
Recovering from Failure	

USAP Tutorial ICSE 2004 - page 33

This list of architecturally-sensitive usability scenarios is compiled from Bass, L., John, B. E., & Kates, J. (2001). *Achieving usability through software architecture* (CMU/SEI-2001-TR-005). Pittsburgh, PA: Software Engineering Institute.

[http://www.sei.cmu.edu/publications/documents/01.ports/01tr005.html](http://www.sei.cmu.edu/publications/documents/01.reports/01tr005.html)

And

Juristo, N., Moreno, A. M., & Sanchez, M. (2003) Deliverable D.3.4. Techniques, patterns and styles for architecture-level usability improvement. - ESPRIT project (IST-2001-32298)

<http://www.ls.fi.upm.es/status/results/deliverables.html>

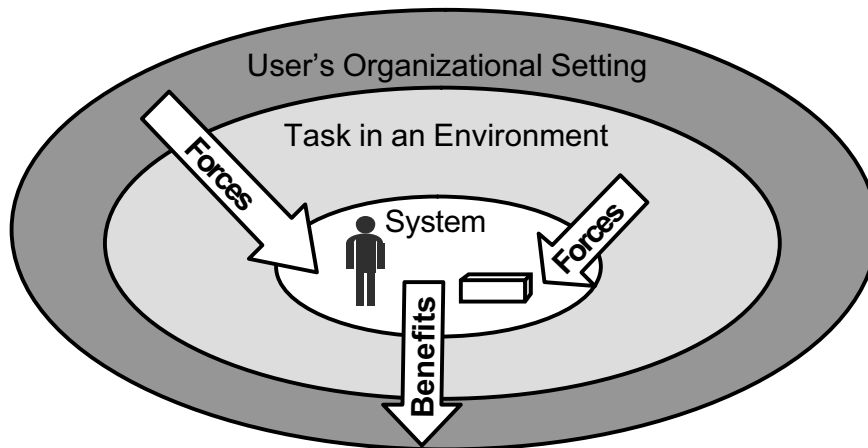
Need more than just architecturally sensitive scenario

Architecturally sensitive scenarios are potential requirements for a particular system to support usability

Need

- to determine whether the benefit of supporting the scenario outweighs the cost
- to provide guidance to the development team as to the issues associated with implementing a solution

Systems exist in a context



USAP Tutorial ICSE 2004 - page 35

Context for computer system

Computer systems fulfill “business” goals

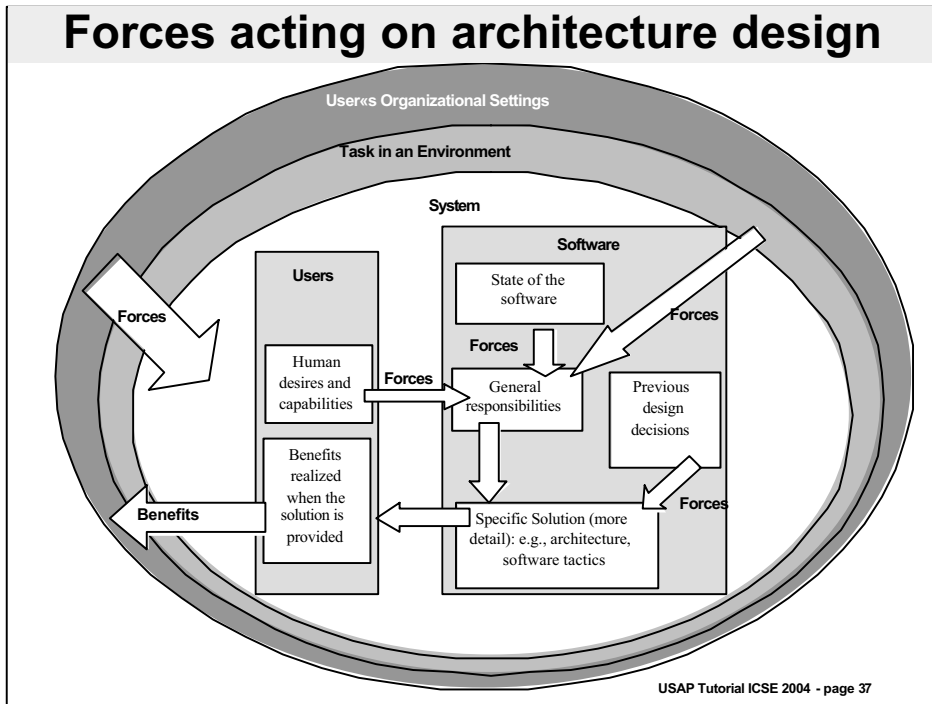
- “Business goals” could be mission, academic, entertainment, etc.
- User using the system creates certain benefits for the “organization” that created it
- Creating system has costs.

Cost/Benefit

- Implementation support for total scenario
- Implementation support for pieces of the scenario

But more detail is necessary to be able to understand cost/benefit and implications of implementation

Forces acting on architecture design



USAP Tutorial ICSE 2004 - page 37

Reasoning about architecture design

Differing forces motivate particular aspects of solution.

Forces come from three sources:

- Task and environment in which user is operating.
 - E.g., Cancel is only useful if operation is long running.
- Human desires and capabilities.
 - E.g., User makes mistakes, Cancel allows one type of correction of mistake.
- State of the software.
 - E.g., Networks fail. Giving the user the ability to cancel may prevent the user from being blocked because of this failure.

Architecture Design

Many different methods for satisfying a particular scenario.

Most systems use separation based architectural pattern as a basis for overall design of system.

We provide two different solutions:

- General solution – responsibilities of the software that must be fulfilled by any solution
- Specific solution. An architectural pattern that shows how to implement the general solution in the context of a separation based pattern. For example, we'll assume J2EE-MVC as an overarching separation based pattern.

USAP Tutorial ICSE 2004 - page 39

Software Architectural Patterns

We have given you two examples of architectural patterns (PAC and J2EE-MVC)

These are examples of the solution portion of an architectural pattern

The patterns community has developed a set of common concepts that should be included in descriptions of a pattern.

We embody these concepts in Usability-Supporting Architectural Patterns (USAPs)

USAP Tutorial ICSE 2004 - page 40

Usability-Supporting Architectural Patterns - 1

Context

- Situation – architecturally sensitive usability scenarios
- Conditions – constraints on when the situation is relevant
- Usability benefits – enumeration of benefits to the user from supporting this scenario

Problem - Forces in conflict

- Forces exerted by the task and environment
- Forces exerted by human desires and capabilities
- Forces exerted by the state of the software when the user wishes to apply the architecturally sensitive usability scenario

USAP Tutorial ICSE 2004 - page 41

Usability-Supporting Architectural Patterns - 2

General solution – set of responsibilities that any solution to situation must satisfy

Specific solution – architectural pattern to solve situation assuming an overarching separation based pattern

- In our slides, we'll assume J2EE-MVC

USAP Context template

Situation: A brief description of the situation from the user's perspective that makes this pattern useful

Conditions on the Situation: Any conditions on the situation constraining when the pattern is useful

Potential Usability Benefits: A brief description of the benefits to the user if the solution is implemented. We use the usability benefit hierarchy given earlier

USAP Tutorial ICSE 2004 - page 43

USAP Context for Cancel - 1

Situation: The user issues a command then changes his or her mind, wanting to stop the operation and return the software to its pre-operation state. It doesn't matter why the user wants to stop; he or she could have made a mistake, the system could be unresponsive, or the environment could have changed.

Conditions on the Situation: A user is working in a system where the software has long-running commands, i.e., more than one second.

The cancellation command could be explicitly issued by the user, or through some sensing of the environment (e.g., a child's hand in a power car window).

Benefits of Cancel - 1

Potential Usability Benefits:

A. Increases individual user effectiveness

A.1 Expedites routine performance

A.1.2 Reduces the impact of routine user errors (slips) by allowing users to revoke accidental commands and return to their task faster than waiting for the erroneous command to complete.

A.2 Improves non-routine performance

A.2.1 Supports problem-solving by allowing users to apply commands and explore without fear, because they can always abort their actions.

Benefits of Cancel – 2

Potential Usability Benefits:

A. Increases individual user effectiveness

A.3 Reduces the impact of user errors caused by lack of knowledge (mistakes)

A.3.2 Accommodates mistakes by allowing users to abort commands they invoke through lack of knowledge and return to their task faster than waiting for the erroneous command to complete.

B. Reduces the impact of system errors

B.2 Tolerates system errors by allowing users to abort commands that aren't working properly (for example, a user cancels a download because the network is jammed).

C. Increases user confidence and comfort by allowing users to perform without fear because they can always abort their actions.

USAP Tutorial ICSE 2004 - page 46

Cost/Benefit

There is a cost to implementing cancel. The software engineer can calculate this.

There is a benefit to the organization (as we explained) from implementing cancel.

- Benefit to current user immediately from recovered time
- Benefit to current user later from cleaning up local resources so system will not subsequently crash
- Benefit to other users from cleaning up shared resources.

Development team (or project manager) can do cost/benefit analysis to determine whether to implement cancel.

First row of problem/general solution template always scenario

The first row provides the rationale for the scenario in terms of the forces.

This enables the development team to decide whether to implement the scenario at all.

It may be that forces are not applicable to current development.

It may also be that forces cause consideration of scenario when it may have been overlooked.

USAP Problem/General Solution Template

Problem			General Solution
Forces exerted by the environment and the task. Each row contains a different force	Forces exerted by human desires and capabilities. Each row contains a different force.	Forces exerted by the state of the software. Each row contains a different force.	Responsibilities of the general solution that resolve the forces in the row.

**Cancel Problem/General Solution:
Responsibility R1 is essentially the
scenario itself**

Problem			General Solution
Networks are sometimes unresponsive.	Users slip or make mistakes, or explore commands and then change their minds, but do not want to wait for the command to complete.	Software is sometimes unresponsive	R1. Must provide a means to cancel a command

USAP Tutorial ICSE 2004 - page 50

Template Problem/General Solution - other rows

Each subsequent row of the problem general solution template provides rationale for one or more responsibilities.

Usually one row per responsibility, but sometimes rationale for multiple responsibilities are the same and so multiple responsibilities are included in one row.

Allows development team to understand reason for responsibility and make cost/benefit decisions about:

- Necessity
- Utility

Cancel Problem/General Solution: Responsibility R2

Problem		General Solution
	Users have to communicate their intentions to the software through overt acts (e.g., finger movements)	Software has to receive an action from the user to do something
		R2. Provide a button, menu item, keyboard shortcut and/or other means to cancel the active command.

USAP Tutorial ICSE 2004 - page 52

Cancel Problem/General Solution: Responsibilities R3 and R4

Problem		General Solution
No one can predict when the environment will change	No one can predict when the users will want to cancel commands	R3. Must always listen for the cancel command or environmental changes R4. Must be always gathering information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command

USAP Tutorial ICSE 2004 - page 53

Appendix contains the full table of forces and general responsibilities for canceling commands.

- We have enumerated 21 responsibilities
- Some are conditional
 - on aspects of the task
 - or state of the software

Summary of responsibilities that any implementation of cancel must consider

- R1. Must provide a means to cancel a command
- R2. Provide a button, menu item, keyboard shortcut and/or other means to cancel the active command.
- R3. Must always listen for the cancel command or environmental changes
- R4. Must always gather information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command
- R5. Must acknowledge receipt of the cancellation command appropriately within 150 msec. The acknowledgement must be appropriate to the manner in which the command was issued. For example, if the user pressed a cancel button, changing the color of the button will be seen. If the user used a keyboard shortcut, flashing the menu that contains that command might be appropriate.

... to R21 (see Tutorial Notes)

USAP Tutorial ICSE 2004 - page 55

Either the command itself is responsive

- R6. The command must have the ability to cancel itself (i.e., it must fulfill Responsibilities R10 to R21 (e.g., an object-oriented system would have a cancel method in each object)

Or the command itself is not responsive

- R7. An active portion of the application must ask the infrastructure to cancel the command, or
- R8. The infrastructure itself must provide a means to request the cancellation of the application (e.g., task manager on Windows, force quit on MacOS)
- R9. If either R7 or R8, then the infrastructure must have the ability to cancel the active command (i.e., it must fulfill Responsibilities R10 to R21)

If the command has invoked collaborating processes

- R10. The collaborating processes have to be informed of the cancellation of the invoking command (these processes have their own responsibilities that they must perform in response to this information, possibly treat it as a cancellation.). The information given to collaborating processes may include the request for cancellation, the progress of cancellation, and/or the completion of cancellation.

Continuation of responsibilities that any implementation of cancel must consider

Either the system is capable of rolling back all changes to the state prior to execution of the command.

R11. Restore the system back to its state prior to execution of the command.

Or the system is not capable of rolling back all changes to the state prior to execution of the command.

R12. Restore the system back to as close to the state prior to execution of the command as possible

R13. Inform the user of the difference between the prior state and the restored state.

Either all resource can be restored

R14. Resources must be freed

Or some resources has been irrevocably consumed and cannot be restored

R15. Inform the user of the partially-restored resources in a manner that they will see it.

For critical tasks with incomplete state or resource restoration,

R16. Require acknowledgement from the user that they are aware of the partially-restored nature of the cancellation.

R17. Return control to the user, or not, depending on the forces from the task

R18. If control cannot be returned to the user, inform the user of this fact (and ideally, why that is the case)

R19. Estimate the time it will take to cancel within 20%

R20. Inform the user of this estimate.

· If the estimate is between 1 and 10 seconds, changing the cursor shape is sufficient.

· If the estimate is more than 10 seconds, and time estimate is with 20%, then a progress indicator is better.

· If estimate is more than 10 seconds but cannot be estimated accurately, consider other alternatives (see TN, footnote 8)

R21. Once the cancellation has finished the system must provide feedback to the user that cancellation is finished, e.g., if cursor was changed to busy indicator, change it back to normal; if progress bar was displayed was displayed, remove it; if dialog box was provided, close it.

Observations on general responsibilities

Many details might be overlooked by implementer

- Free resources
- Provide feedback if not able to completely cancel
- Inform collaborators

Table provides rationale which enables cost/benefit possibilities. e.g. “return control to the user immediately”

- Benefit is that user wants to multi-task – increased efficiency
- Cost may be too high depending on system environment.

USAP Tutorial ICSE 2004 - page 57

Small Group Exercise:

Apply the problem statement and forces to a real-world problem brought by the members of the breakout group.
(one group per instructor)

Report-out to the entire group

LUNCH

USAP Tutorial ICSE 2004 - page 59

Overarching patterns

Designers do not build system design around desire for architecturally sensitive usability scenarios.

Designers have some overarching pattern that they use.
e.g. PAC or J2EE-MVC

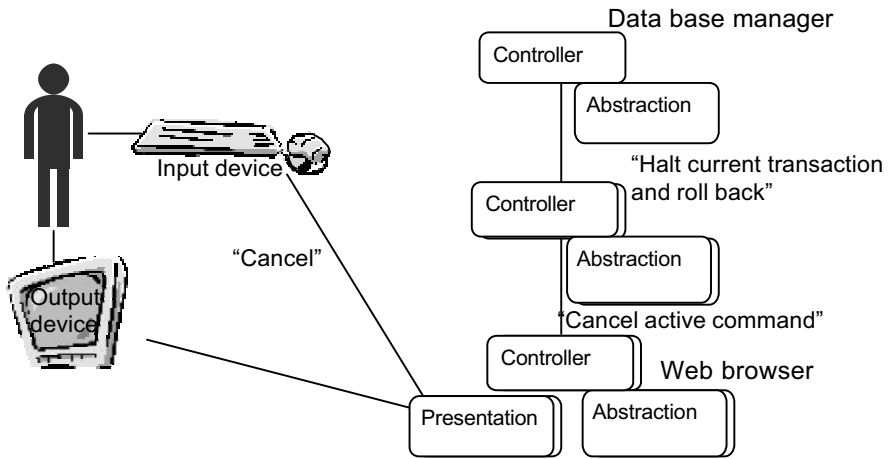
This overarching pattern introduces additional software forces on specific solution.

Consider “inform collaborating processes” responsibility when canceling web-based data base application.

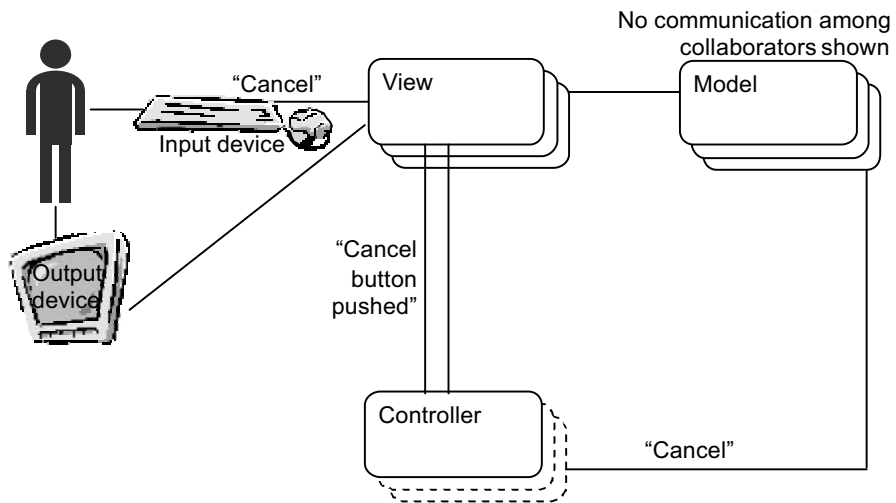
Notice the difference in communication from PAC to J2EE-MVC

USAP Tutorial ICSE 2004 - page 60

Presentation-Abstraction-Control (PAC)



J2EE MVC version of “inform collaborators”



We'll use J2EE-MVC as overarching pattern to illustrate our USAPs

Overarching pattern will affect specific solution in our USAPs

We'll use J2EE-MVC as overarching pattern because it is widely used in web applications.

Open question as to how, in general, choice of a different overarching pattern would affect specific solutions

We'll use a non-critical task for the example

This implies that

- The user can have control while the cancellation is happening
- The user need not acknowledge the results of the cancellation

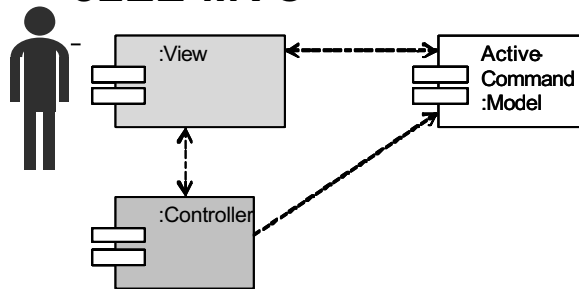
Specific Solution

Architectural view: Presentation of one (or more) aspects of the architecture.

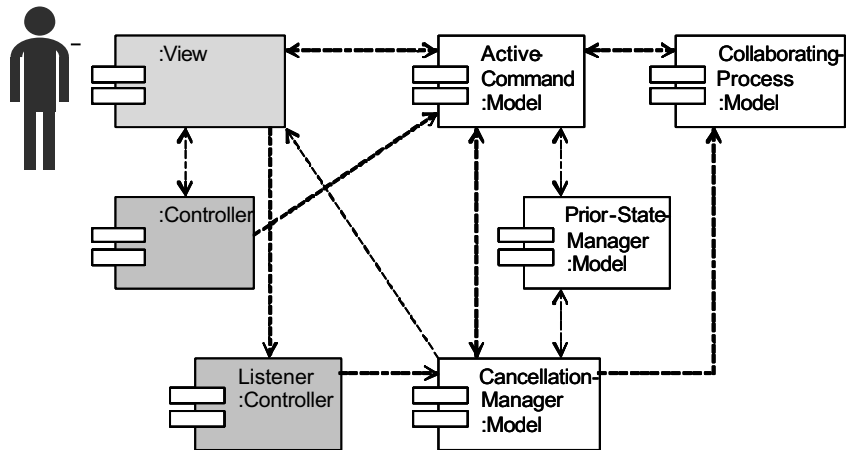
Common views:

- Component Diagram – shows major units of software but does not show dynamic behavior or assignment of units to various processors.
- Sequence Diagram – shows sequence of activities for a single thread through the system

Context of the specific solution: J2EE-MVC



Component diagram for a specific solution to Cancel



USAP Tutorial ICSE 2004 - page 67

Responsibilities of new component – Listener

- Type Controller
- Must always listen for the cancel command or environmental changes (R3)

Responsibilities of new component – Cancellation Manager

- Type Model
- Always listen and gather information (R3, R4)
- If the Active Command is not responding, handle the cancellation (R7, R10, R11, R12)
- Free resources (R14)
- Estimate time to cancel (R19)
- Inform the user of Progress of the cancellation (R13, R15, R20, R21)

USAP Tutorial ICSE 2004 - page 69

Full text of responsibilities assigned to the Cancellation Manager in this example solution

R3. Must always listen for the cancel command or environmental changes

R4. Must always gather information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command

R7. An active portion of the application must ask the infrastructure to cancel the command,

If R7, then R10. The collaborating processes have to be informed of the cancellation of the invoking command (these processes have their own responsibilities that they must perform in response to this information, possibly treat it as a cancellation.). The information given to collaborating processes may include the request for cancellation, the progress of cancellation, and/or the completion of cancellation.

If R7, then R11. Restore the system back to its state prior to execution of the command. OR
R12. Restore the system back to as close to the state prior to execution of the command as possible

If R12, then R13. Inform the user of the difference between the prior state and the restored state.

R14. All resources that can be freed must be freed.

If any resources are not capable of being freed, then R15. Inform the user of the partially-restored resources in a manner that they will see it.

R19. Estimate the time it will take to cancel within 20%

R20. Inform the user of this estimate.

R21. Once the cancellation has finished the system must provide feedback to the user that cancellation is finished, e.g., if cursor was changed to busy indicator, change it back to normal; if progress bar was displayed, remove it; if dialog box was provided, close it.

Responsibilities of new component – Prior State Manager

- Type Model
- Must always gather information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command (R4)
- If the Active Command is not responding (R7), work with the Cancellation Manager to restore the system back to its state prior to execution of the command (R11) or as close as possible to that state (R12)

New responsibilities for old components - View

- Type View
- Provide a button, menu item, keyboard shortcut and/or other means to cancel the active command (R2)
- Must always listen for the cancel command or environmental changes (R3)
- Provide feedback to the user about the progress of the cancellation (R5, R13, R15, R20, R21)

USAP Tutorial ICSE 2004 - page 71

Full text of responsibilities assigned to the View in this example solution

R2. Provide a button, menu item, keyboard shortcut and/or other means to cancel the active command

R3. Must always listen for the cancel command or environmental changes

R5. Must acknowledge receipt of the cancellation command appropriately within 150 msec.

If any module did R12, then R13. Inform the user of the difference between the prior state and the restored state.

If any module did R14, then R15. Inform the user of the partially-restored resources in a manner that they will see it.

R20. Inform the user of the time estimate.

R21. Once the cancellation has finished the system must provide feedback to the user that cancellation is finished, e.g., if cursor was changed to busy indicator, change it back to normal; if progress bar was displayed was displayed, remove it; if dialog box was provided, close it.

New responsibilities for old components - Active Command

- Type Model
- Always gather information (R4)
- Handle the cancellation by terminating processes, and restoring state and resources (R6, R10, R11, R12, R14)
- Provide appropriate feedback to the user (R13, R15, R19, R20, R21)

USAP Tutorial ICSE 2004 - page 72

Full text of responsibilities assigned to the Active Command in this example solution

- R4. Must always gather information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command
- R6. The command must respond by canceling itself (I.e., it must fulfill Responsibilities R10 to R21 (e.g., an object-oriented system would have a cancel method in each object)
- If R6 then R10. The collaborating processes have to be informed of the cancellation of the invoking command (these processes have their own responsibilities that they must perform in response to this information, possibly treat it as a cancellation.). The information given to collaborating processes may include the request for cancellation, the progress of cancellation, and/or the completion of cancellation.
- If R6, then R11. Restore the system back to its state prior to execution of the command. Or R12. Restore the system back to as close to the state prior to execution of the command as possible
- If R12, then R13. Inform the user of the difference between the prior state and the restored state.
- R14. Resources that can be freed must be freed
- If any resources are not capable of being freed, then R15. Inform the user of the partially-restored resources in a manner that they will see it.
- R19. Estimate the time it will take to cancel within 20%
- R20. Inform the user of this estimate.
- R21. Once the cancellation has finished the system must provide feedback to the user that cancellation is finished, e.g., if cursor was changed to busy indicator, change it back to normal; if progress bar was displayed, remove it; if dialog box was provided, close it.

Responsibilities not assigned or shown in our diagrams and why.

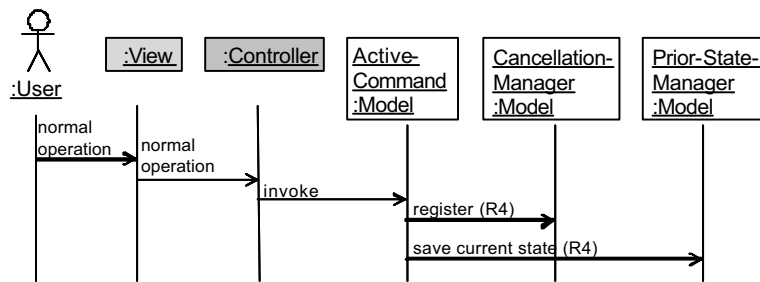
- We are not considering a “critical task” where the progress and results of the cancellation must effect user behavior, therefore R16 and R18 are not assigned.
- J2EE-MVC implicitly returns control to the user during cancellation, so R17 is not assigned.
- Our diagram does not show the infrastructure in which the application runs, therefore responsibilities assigned to the infrastructure are not shown (R8, R9)

USAP Tutorial ICSE 2004 - page 73

List of responsibilities not assigned to our components or not shown in the diagrams.

- R8. The infrastructure itself must provide a means to request the cancellation of the application (e.g., task manager on Windows, force quit on MacOS)
- R9. If either R7 or R8, then the infrastructure must have the ability to cancel the active command (I.e., it must fulfill Responsibilities R10 to R21)
- R16 Require acknowledgement from the user that they are aware of the partially-restored nature of the cancellation. (we’re not doing a “critical task” in this example)
- R17. Return control to the user, or not, depending on the forces from the task (implicit in J2EE-MVC)
- R18. If control cannot be returned to the user, inform the user of this fact (and ideally, why that is the case) (we’re not doing a “critical task” in this example)

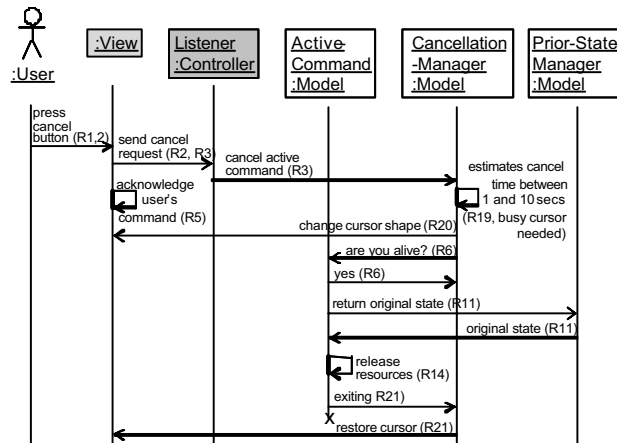
Sequence diagram of activities prior to issuing cancel command



USAP Tutorial ICSE 2004 - page 74

Xxx put in note about the components that don't show up in this sequence

Sequence diagram of activities after issuing cancel command



USAP Tutorial ICSE 2004 - page 75

Xxx put in note about the components that don't show up in this sequence

Comment on sequence diagrams

Important portion of cancel is that listener is on separate thread of control (otherwise listener may be blocked because command is not responding and command owns the active thread).

Sequence diagram does not make this explicit. It is implicit in fact that listener responds regardless of state of active command.

Sequence diagram is UML (standard). Difficult to show threads in UML.

Small Group Exercise

Apply sample solution to real-world problem introduced in prior break out

Report-out to entire group

BREAK

USAP Tutorial ICSE 2004 - page 78

Schedule

Time	Topic
4:00-5:15	A second USAP: ?Example with Observing System State USAP

A Second USAP

Observing System State

USAP Tutorial ICSE 2004 - page 80

Types of Feedback

- **Observing System state:** To inform users of the internal system state and state changes.
- **Progress indicator:** To inform users that the system is processing an action that will take some time to complete.
- **Interaction Feedback:** To inform users that the system has registered a user interaction, that is, that the system has heard users.
- **Warning:** To inform users of any irreversible action.

USAP Template

- **Context**
 - Situation
 - Conditions
 - Potential usability benefits
- Problem and General Solution
- Specific Solution

USAP Tutorial ICSE 2004 - page 82

Observing System State:

Situation

Situation: When some change in system state occurs, the user should be notified, specially when the state change affects to state information that is displayed.

Conditions

Potential Usability Benefits

Observing System State: Conditions

Situation: When some change in system state occurs, the user should be notified.

Conditions:

- A user may not be given the system state data necessary to operate the system (e.g., uninformative error messages, no file size given for folders).
- The system state may be given in a way that violates human tolerances (e.g., displayed too quickly for people to read).
- The system state may also be given unclearly, thereby confusing the user.
- System designers should account for human needs and capabilities when deciding what aspects of a system state to display and how to do so.

Potential Usability Benefits

USAP Tutorial ICSE 2004 - page 84

Observing System State: Potential Usability Benefits

Situation: When some change in system state occurs, the user should be notified.

Conditions:


- A user may not be given the system state data necessary to...

Potential Usability Benefits:

- A. Increase individual user effectiveness
 - A.1 Expedite routine performance
 - A.1.2 Reduce the impact of routine user errors (slips)
 - A.2 Improve non-routine performance
 - A.2.1 Support problem-solving
 - A.2.2 Facilitate learning
 - A.3 Reduce the impact of user mistakes
 - A.3.2 Accommodate mistakes
- C. Increase user confidence and comfort

USAP Tutorial ICSE 2004 - page 85

USAP Template

- Context
- **Problem and General Solution** 
- Specific Solution

USAP Template

- Context
- **Problem and General Solution**
 - Forces exerted by the environment and the task
 - Forces exerted by human desires and capabilities
 - Forces exerted by the state of the software
 - Responsibilities of the general solution that resolve the forces
- Specific Solution

Observing System State: Human Forces (1/2)

1. When some change in system state occurs, the user should be notified (HF01)
2. If the system fails, the user should be notified (HF02)
3. Users need to be alerted of the fact that a command does not respond (HF03)

Observing System State: Environmental Forces

1. Resources, be it the network, a database, etc., can become not operational (EF01)

Observing System State: System Forces (1/2)

1. System state changes (SF01)
2. Systems sometimes fail (SF02)
3. Commands sometimes die (SF03)

Observing System State: Problem - Responsibilities

Problem			General Solution
Forces exerted by the environment and the task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software	Responsibilities of the software system that resolve the forces

USAP Tutorial ICSE 2004 - page 91

Observing System State: Problem - Responsibilities

Problem/Forces:

- SF01. The software changes
- HF01. When some change in system state occurs, the user should be notified.

Solution/Responsibilities:

- R01. The software should be able to listen to active commands, because they can provide information about the state of the system. If this information is useful to the user, the system should be able to provide this information to the user in the appropriate manner and in the proper location.

Observing System State: Problem - Responsibilities

Problem/Forces:

- SF03: Commands sometimes fail to be operational
- HF02: If the system fails, the user should be notified
- HF03: To alert users of the fact that a command does not respond

Solution/Responsibilities:

- R02: As active commands can fail, the software system should be able to check at any time whether a given command is being executed and, if the command fails, inform users that the command is not operational.

Observing System State: Problem - Responsibilities

Problem/Forces:

- EF1: Resources, be it the network, a database, etc., can become not operational

Solution/Responsibilities:

- R03: The software should be able to listen to or query external resources, like networks or databases, about their state, to inform properly the user if any resource is not performing properly.

Observing System State: Problem - Responsibilities

Problem/Forces:

- HF01. When some change in system state occurs, the user should be notified.

Solution/Responsibilities:

- R04: The software should be able to check the system resources and inform the user about their use.

USAP Template

- Context
- Problem and General Solution
- **Specific Solution**
 - General responsibilities
 - Forces exerted by previous design decisions
 - Allocation of responsibilities to specific components
 - Rationale

USAP Tutorial ICSE 2004 - page 96

Observing System State: General Responsibilities

- R01: Listen to active commands
- R02: Ascertain the state of active commands
- R03: Listen to or query external sources
- R04: Check the state of system resources

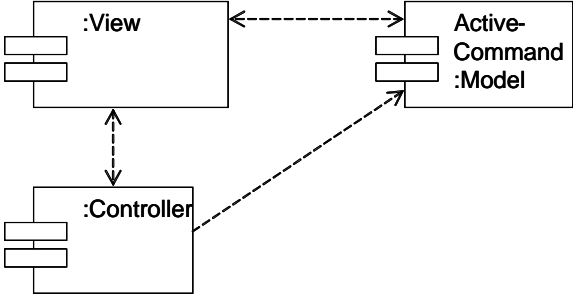


USAP Tutorial ICSE 2004 - page 97

Observing System State: Forces from design decisions

- Architectural styles for the system will affect specific solution
- We have used J2EE-MVC as an architectural style for designing a specific solution

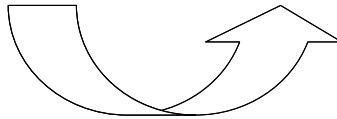
Context of the specific solution: J2EE-MVC



Observing System State: Allocation of responsibilities

R1. The software should be able to listen to active commands. If this information is useful to the user, the system should be able to provide this information to the user in the appropriate manner not only through the display.

- **Model:** Should include an element that listens to active commands and, if the info is useful, sends it to the controller.
- **View:** Should be able to inform the user in the appropriate manner.
- **Controller:** Should be able to select the appropriate view to show the information to the user.

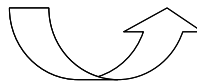
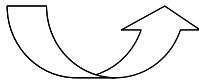


USAP Tutorial ICSE 2004 - page 100

Observing System State: Allocation of responsibilities

R1

- **Model:** Should include an element that listens to active commands and, if the info is useful, sends it to the controller.
- **View:** Should be able to inform the user in the appropriate manner.
- **Controller:** Should be able to select the appropriate view to show the information to the user.



- **Active Command:** Represents the command in progress and should inform the appropriate feedbacker if the user is to be notified of something
- **Feedbacker:** Receives the information to be displayed from the model or a change of view from the controller
- **Controller:** Should be listening to the Viewer and, if the user requests an action creates the required command, an instance of active command



USAP Tutorial ICSE 2004 - page 101

Observing System State: Allocation of responsibilities

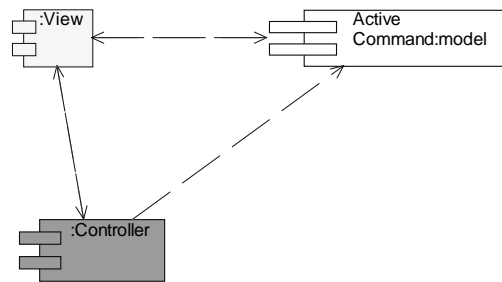
General Responsibilities of the software	Forces exerted by previous design decisions	Allocation of responsibilities to specific components
<p>R01: The software should be able to listen to active commands, because they can provide information about the state of the system. If this information is useful to the user, the system should be able to provide this information to the user in the appropriate manner and in the appropriate location, not only through the display.</p>	<p>Model: The model should include an element that listens to active commands and, if the information is useful, sends the information to be passed on to the user (see model decomposition)</p>	<p>Active command: Represents the command in progress and should inform appropriate feedbacker if the user is to be notified of something</p>
	<p>View: Should be able to inform the user in the appropriate manner.</p>	<p>Feedbacker: Receives the information to be displayed from the model or a change of view from the controller</p>
	<p>Controller: Should be able to select the appropriate view to show the information to the user.</p>	<p>Controller: Should be listening to the Viewer and, if the user requests an action creates the required command, an instance of active command</p>



Observing System State: Specific Solution

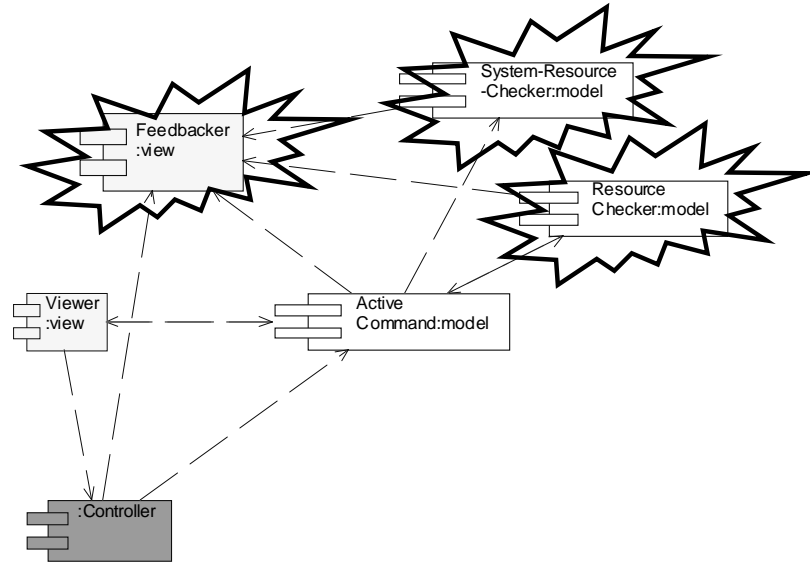
- Check whether or not the ongoing command is dead.
- Check whether or not external resources are dead.
- Check whether or not the system has enough resources to execute the ongoing command.

Observing System State: Specific Solution



USAP Tutorial ICSE 2004 - page 104

Observing System State: Specific Solution

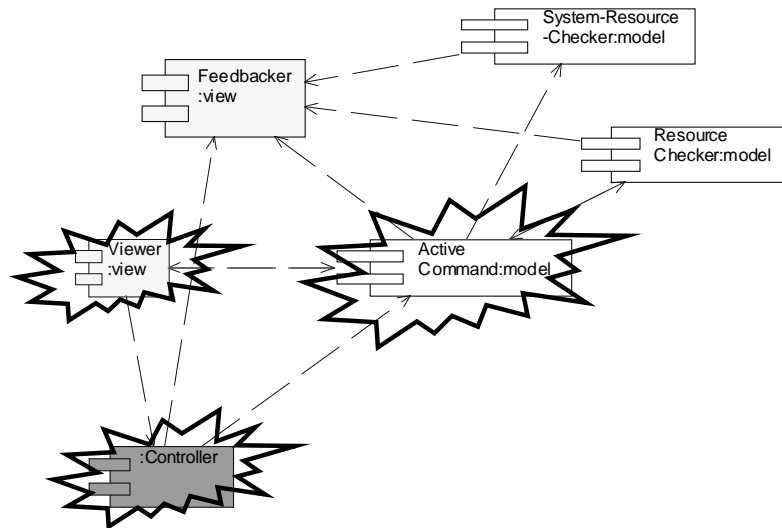


USAP Tutorial ICSE 2004 - page 105

Observing System State: Responsibilities of new components

NEW COMPONENT	RESPONSIBILITIES
Feedbacker <i>(Type Model)</i>	Receive info from Resource Checker and select the appropriate feedback (R02, R03, R04)
Resource Checker <i>(Type Model)</i>	Must be able to check whether or not the ongoing command is alive (R02) Must be able to check whether or not the external resources are alive (R03)
System Resource Checker <i>(Type Model)</i>	Must be able to check whether or not the system can provide enough resources to properly execute the ongoing command (R04)

Observing System State: Specific Solution



USAP Tutorial ICSE 2004 - page 107

Observing System State: Responsibilities of old components

OLD COMPONENT	RESPONSABILITIES
Viewer (Type View)	Must be able to gather user requests.
Controller (Type Controller)	Must always listen for the viewer requests to create the respective active command.
Active Command (Type Model)	Represents the command in progress and should inform the Feedbacker about any change produced.

USAP Tutorial ICSE 2004 - page 108

Observing System State: Responsibilities related to control

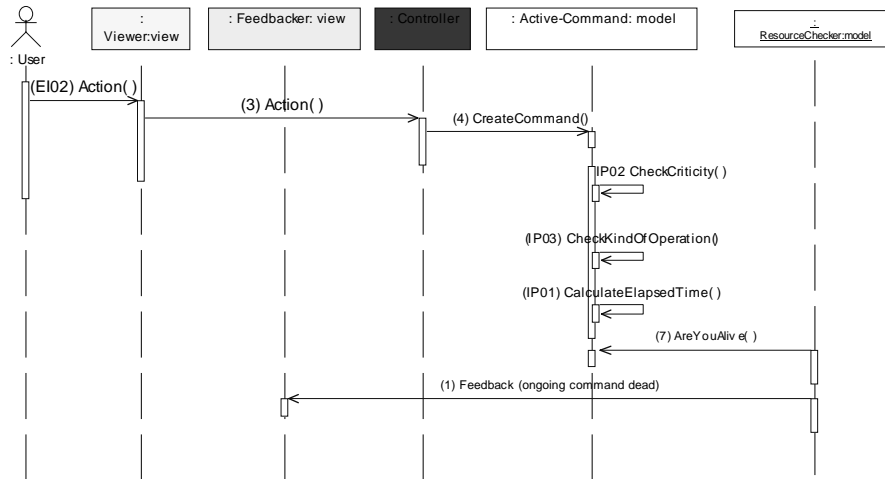
- The Active Command should run in a different thread from the Resource Checker component
- The Active Command should run in a different thread from the System Resource Checker component

Observing System State: Specific Solution

Imagine we are faced with a situation where:

- The ongoing command is dead

Observing System State: Specific Solution

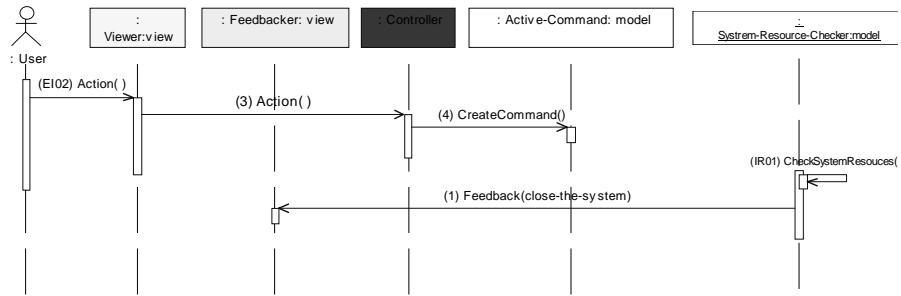


Observing System State: Specific Solution

Imagine we are faced with a situation where:

- There are not enough resources to execute the ongoing command

Observing System State: Specific Solution

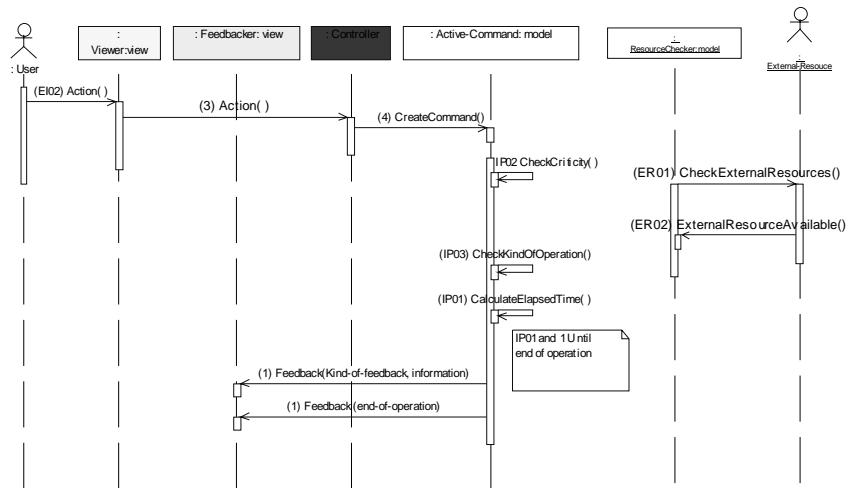


Observing System State: Specific Solution

Imagine we are faced with a situation where:

- The external resources are performing properly

Observing System State: Specific Solution



Current status of USAPs

We have about two dozen architecturally sensitive scenarios

Four of these have been elaborated into force => general responsibilities

We are elaborating additional scenarios.

We are also looking for additional scenarios.

Goal is to produce a handbook.

Experiences of USAPs in development

Several Architectural Tradeoff Analyses conducted by the SEI used some of the architecturally-sensitive usability scenarios

NASA's MERBoard, a large-screen collaborative tool used in the Mars Exploration Rover mission this winter, redesigned their architecture using the scenarios and USAPs

Tutorial Summary

Software architectural design can support iterative design through separation based patterns, but some usability issues are difficult to resolve through iterative design.

Architecturally sensitive scenarios are examples of problems that are difficult to implement once architecture is designed.

USAPs are an attempt to capture some of these problems, provide rationale to support cost/benefit analysis, provide general set of responsibilities for any solution, and provide sample specific solution to further guide software designer.

Currently have about two dozen architecturally sensitive scenarios and are in process of turning these into USAPs.

USAP Tutorial ICSE 2004 - page 118

Appendix I

General Usability Scenarios

(excerpt of Bass, L., John, B. E., & Kates, J. (2001). Achieving usability through software architecture (CMU/SEI-2001-TR-005). Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University)

This section enumerates the usability scenarios that we have identified as being architecturally sensitive. A general usability scenario describes an interaction that some stakeholder (e.g., end user, developer, system administrator) has with the system under consideration from a usability point of view.

We generated the list of usability scenarios by surveying the literature, by personal experience, and by asking colleagues [Gram 1996, Newman 1995, Nielsen 1993]. We also screened the list so that all entries have explicit software architectural implications and solutions. Section 5 provides an architectural pattern that implements each scenario given in this report.

1. Aggregating Data

A user may want to perform one or more actions on more than one object. For example, an Adobe® Illustrator® user may want to enlarge many lines in a drawing. It could become tedious to perform these actions one at a time. Furthermore, the specific aggregations of actions or data that a user wishes to perform cannot be predicted; they result from the requirements of each task. Systems, therefore, should allow users to select and act upon arbitrary combinations of data.

2. Aggregating Commands

A user may want to complete a long-running, multi-step procedure consisting of several commands. For example, a psychology researcher may wish to execute a batch of commands on a data file during analysis. It could become tedious to invoke these commands one at a time, or to provide parameters for each command as it executes. If the computer is unable to accept the required inputs for this procedure up front, the user will be forced to wait for each input to be requested. Systems should provide a batch or macro capability to allow users to aggregate commands.

3. Canceling Commands

A user invokes an operation, then no longer wants the operation to be performed. The user now wants to stop the operation rather than wait for it to complete. It does not matter why the user launched the operation. The mouse could have slipped. The user could have mistaken one command for another. The user could have decided to invoke another operation. For these reasons (and many more), systems should allow users to cancel operations.

4. Using Applications Concurrently

A user may want to work with arbitrary combinations of applications concurrently. These applications may interfere with each other. For example, some versions of IBM® Via-Voice and Microsoft® Word contend for control of the cursor with unpredictable results.

Systems should ensure that users can employ multiple applications concurrently without conflict. (See: Supporting Multiple Activities)

5. Checking for Correctness

A user may make an error that he or she does not notice. However, human error is frequently circumscribed by the structure of the system; the nature of the task at hand, and by predictable perceptual, cognitive, and motor limitations. For example, users often type “hte” instead of “the” in word processors. The frequency of the word “the” in English and the fact that “hte” is not an English word, combined with the frequency of typing errors that involve switching letters typed by alternate hands, make automatically correcting to “the” almost always appropriate. Computer-aided correction becomes both possible and appropriate under such circumstances. Depending on context, error correction can be enforced directly (e.g., automatic text replacement, fields that only accept numbers) or suggested through system prompts.

6. Maintaining Device Independence

A user attempts to install a new device. The device may conflict with other devices already present in the system. Alternatively, the device may not function in certain specific applications. For example, a microphone that uses the Universal Serial Bus (USB) may fail to function with older sound software. Systems should be designed to reduce the severity and frequency of device conflicts. When device conflicts occur, the system should provide the information necessary to either solve the problem or seek assistance. (Devices include printers, storage/media, and I/O apparatus.)

7. Evaluating the System

A system designer or administrator may be unable to test a system for robustness, correctness, or usability in a systematic fashion. For example, the usability expert on a development team might want to log test users’ keystrokes, but may not have the facilities to do so. Systems should include test points and data gathering capabilities to facilitate evaluation.

8. Recovering from Failure

A system may suddenly stop functioning while a user is working. Such failures might include a loss of network connectivity or hard drive failure in a user’s PC. In these or other cases, valuable data or effort may be lost. Users should be provided with the means to reduce the amount of work lost from system failures.

9. Retrieving Forgotten Passwords

A user may forget a password. Retrieving and/or changing it may be difficult or may cause lapses in security. Systems should provide alternative, secure mechanisms to grant users access. For example, some online stores ask each user for a maiden name, birthday, or the name of a favorite pet in lieu of a forgotten password.

10. Providing Good Help

A user needs help. The user may find, however, that a system’s help procedures do not adapt adequately to the context. For example, a user’s computer may crash. After re-

booting, the help system automatically opens to a general table of contents rather than to a section on restoring lost data or searching for conflicts. Help content may also lack the depth of information required to address the user's problem. For example, an operating system's help area may contain an entry on customizing the desktop with an image, but may fail to provide a list of the types of image files that can be used. Help procedures should be context dependent and sufficiently complete to assist users in solving problems.

11. Reusing Information

A user may wish to move data from one part of a system to another. For example, a telemarketer may wish to move a large list of phone numbers from a word processor to a database. Re-entering this data by hand could be tedious and/or excessively time-consuming. Users should be provided with automatic (e.g., data propagation) or manual (e.g., cut and paste) data transports between different parts of a system. When such transports are available and easy to use, the user's ability to gain insight through multiple perspectives and/or analysis techniques will be enhanced.

12. Supporting International Use

A user may want to configure an application to communicate in his or her language or according to the norms of his or her culture. For example, a Japanese user may wish to configure the operating system to support a different keyboard layout. However, an application developed in one culture may contain elements that are confusing, offensive, or otherwise inappropriate in another. Systems should be easily configurable for deployment in multiple cultures.

13. Leveraging Human Knowledge

People use what they already know when approaching new situations. Such situations may include using new applications on a familiar platform, a new version of a familiar application, or a new product in an established product line.

New approaches usually bring new functionality or power. When, however, users are unable to apply what they already know, a corresponding cost in productivity and training time is incurred. For example, new versions of applications often assign items to different menus or change their names. As a result, users skilled in the older version are reduced to the level of novices again, searching menus for the function they know exists.

System designers should strive to develop upgrades that leverage users' knowledge of prior systems and allow them to move quickly and efficiently to the new system.

14. Modifying Interfaces

Iterative design is the lifeblood of current software development practice, yet a system developer may find it prohibitively difficult to change the user interface of an application to reflect new functions and/or new presentation desires. System designers should ensure that their user interfaces can be easily modified.

15. Supporting Multiple Activities

Users often need to work on multiple tasks more or less simultaneously (e.g., check mail and write a paper). A system or its applications should allow the user to switch quickly back and forth between these tasks.

16. Navigating Within a Single View

A user may want to navigate from data visible on-screen to data not currently displayed. For example, he or she may wish to jump from the letter “A” to the letter “Q” in an on-line encyclopedia without consulting the table of contents. If the system takes too long to display the new data or if the user must execute a cumbersome command sequence to arrive at her or his destination, the user’s time will be wasted. System designers should strive to ensure that users can navigate within a view easily and attempt to keep wait times reasonably short. (See: Working at the User’s Pace)

17. Observing System State

A user may not be presented with the system state data necessary to operate the system (e.g., uninformative error messages, no file size given for folders). Alternatively, the system state may be presented in a way that violates human tolerances (e.g., is presented too quickly for people to read. See: Working at the User’s Pace). The system state may also be presented in an unclear fashion, thereby confusing the user. System designers should account for human needs and capabilities when deciding what aspects of system state to display and how to present them.

A special case of Observing System State occurs when a user is unable to determine the level of security for data entered into a system. Such experiences may make the user hesitate to use the system or avoid it altogether.

18. Working at the User’s Pace

A system might not accommodate a user’s pace in performing an operation. This may make the user feel hurried or frustrated. For example, ATMs often beep incessantly when a user “fails” to insert an envelope in time. Also, Microsoft Word’s scrolling algorithm does not take system speed into account and becomes unusable on fast systems (the data flies by too quickly for human comfort). Systems should account for human needs and capabilities when pacing the stages in an interaction. Systems should also allow users to adjust this pace as needed.

19. Predicting Task Duration

A user may want to work on another task while a system completes a long running operation. For example, an animator may want to leave the office to make copies or to eat while a computer renders frames. If systems do not provide expected task durations, users will be unable to make informed decisions about what to do while the computer “works.” Thus, systems should present expected task durations.

20. Supporting Comprehensive Searching

A user wants to search some files or some aspects of those files for various types of content. For example, a user may wish to search text for a specific string or all movies for a

particular frame. Search capabilities may be inconsistent across different systems and media, thereby limiting the user's opportunity to work. Systems should allow users to search data in a comprehensive and consistent manner by relevant criteria.

21. Supporting Undo

A user performs an operation, then no longer wants the effect of that operation. For example, a user may accidentally delete a paragraph in a document and wish to restore it. The system should allow the user to return to the state before that operation was performed. Furthermore, it is desirable that the user then be able to undo the prior operation (multi-level undo).

22. Working in an Unfamiliar Context

A user needs to work on a problem in a different context. Discrepancies between this new context and the one the user is accustomed to may interfere with the ability to work. For example, a clerk in business office A wants to post a payment for a customer of business unit B. Each business unit has a unique user interface, and the clerk has only used unit A's previously. The clerk may have trouble adapting to business unit B's interface (same system, unfamiliar context.) Systems should provide a novice (verbose) interface to offer guidance to users operating in unfamiliar contexts.

23. Verifying Resources

An application may fail to verify that necessary resources exist before beginning an operation. This failure may cause errors to occur unexpectedly during execution. For example, some versions of Adobe® PhotoShop® may begin to save a file only to run out of disk space before completing the operation. Applications should verify that all necessary resources are available before beginning an operation.

24. Operating Consistently Across Views

A user may become confused by functional deviations between different views of the same data. Commands that had been available in one view may become unavailable in another or may require different access methods. For example, users cannot run a spell check in the Outline View utility found in a mid-90's version of Microsoft Word. Systems should make commands available based on the type and content of a user's data, rather than the current view of that data, as long as those operations make sense in the current view.

For example, allowing users to perform operations on individual points in a scatter plot while viewing the plot at such a magnification that individual points cannot be visually distinguished does not make sense. A naïve user is likely to destroy the underlying data. The system should prevent selection of single points when their density exceeds the resolution of the screen, and inform the user how to zoom in, access the data in a more detailed view, or otherwise act on single data points. (See: Providing Good Help and Supporting Visualization)

25. Making Views Accessible

Users often want to see data from other viewpoints. For example, a user may wish to see the outline of a long document and the details of the prose. If certain views become un-

available in certain modes of operation, or if switching between views is cumbersome, the user's ability to gain insight through multiple perspectives will be constrained. (See: Supporting Visualization)

26. Supporting Visualization

A user wishes to see data from a different viewpoint. Systems should provide a reasonable set of task-related views to enhance users' ability to gain additional insight while solving problems. For example, Microsoft Word provides several views to help users compose documents, including Outline and Page Layout modes.

27. Supporting Personalization **(not in CMU/SEI-2001-TR-005)**

A user wants to work in a particular configuration of features that the system provides. The user may want this configuration to persist over multiple uses of the system (as opposed to having to set it up each time). Systems should enable a user to specify their preferences for features and provide the possibility for these preferences to endure. For example, customizing Netscape's toolbar or saving a hierarchical structure of bookmarks.

Appendix II

Details of the Usability Benefit Hierarchy

(excerpt from Bass, L., John, B. E., & Kates, J. (2001). Achieving usability through software architecture (CMU/SEI-2001-TR-005). Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University)

To create usable systems, designers must first ensure that their proposed products provide the functionality their users actually need to perform work as opposed to the functionality that the marketing or development team imagines they need. In other words, systems must provide functionality that fits the individual, organizational, and social structure of the work context. Although specifying and identifying needed functionality are fundamental steps in the development process, these design phases do not typically involve architectural concerns. Thus, we will not discuss them here. (We refer readers interested in these issues to *Contextual Design* [Beyer 1998].)

Assuming that the functionality needed by a system's users is correctly identified and specified, the usability of such a system can still be seriously compromised by architectural decisions that hinder or even prevent the required benefits. In extreme cases, the resulting system can become virtually unusable.

This section organizes and presents scenarios by their usability benefits. We arrived at the hierarchy of usability benefits presented in Table 1 using a bottom-up process called the affinity process [Beyer 1998]. We took this approach rather than taking an existing definition of usability and sorting the scenarios into it because it was not clear that architecturally sensitive scenarios would cover the typical range of usability benefits. However, the resulting hierarchy does not differ significantly from organizations of usability given by other authors [e.g., Newman 1995; Nielsen 1993; Shneiderman 1998], and we view this as partial confirmation that our set of architecturally sensitive scenarios covers, in some sense, the usability space. Each scenario occurs in one or more positions in the hierarchy.

The entries in this chapter discuss each item of the usability benefit hierarchy. One premise of this work has been that the design of a system embodies tradeoffs between benefits (usability) and cost (software engineering). Hence in each section, we discuss the appropriate messages for each benefit. This will enable the usability engineer to better argue the potential benefits of each scenario and the software engineer to know what instrumentation should be embedded into the system to support the benefit calculations.

Table 1. Usability Benefits Hierarchy

Increases individual user effectiveness

Expedites routine performance

Accelerates error-free portion of routine performance

Reduces the impact of routine user errors (slips)

Improves non-routine performance

Supports problem-solving

Facilitates learning

Reduces the impact of user errors caused by lack of knowledge (mistakes)

Prevents mistakes

Accommodates mistakes

Reduces the impact of system errors

Prevents system errors

Tolerates system errors

Increases user confidence and comfort

1 Increases Individual User Effectiveness

If addressed properly, the scenarios included in this category will improve the performance of individual users. Such increases in productivity, though seemingly small when considered discretely, can aggregate to produce substantial benefits for an organization as a whole.

1.1 Expedites routine performance

In a routine task, a user recognizes a situation, knows what the next goal should be, and knows what to do to accomplish that goal. No problem-solving is necessary. All that remains is for the user to recall and execute the commands necessary to complete the task.

When performing routine tasks, even skilled users will become faster but will probably not develop new methods to complete their tasks [Card 1983]. This is in contrast to a problem-solving or learning situation where the user is likely to discover or learn a new method while performing a task. (For an example of learning and problem-solving behavior, see non-routine performance.)

Although users know what to do to accomplish routine tasks, they will still make errors. In fact, observations of skilled users performing routine tasks reveal that about 20% of a user's time may be consumed by making, then recovering from, mistakes. These "routine errors" result from "slips" in execution (e.g., hitting the wrong key or selecting the menu item next to the one desired), rather than from a lack of knowledge (i.e., not knowing which command to use). Slips can never be totally prevented if there are multiple actions available to a user, but some system designs accommodate these errors more successfully than others.

Accelerates error-free portion of routine performance

Routine tasks take time for a user to recognize the situation, recall the next goal and the method used to accomplish it, and to mentally and/or physically execute the commands to accomplish the goal. We call the minimum required time to accomplish a task, assuming no slips, the error-free portion of routine performance.

In practice, the actual performance time is the sum of this minimum time and the time it takes to make and recover from slips. Systems can be designed to maximize error-free performance time, thereby reducing time to perform routine tasks and increasing individual effectiveness.

Reduces the impact of routine user errors (slips)

The negative impact of routine user errors can be reduced in two ways. First, since users will always slip, reducing the number of opportunities for error (roughly corresponding to the number and difficulty of steps in a given procedure) will usually reduce its occurrence. Second, systems can be designed to better accommodate user slips by providing adequate recovery methods.

1.2 Improves non-routine performance

In a non-routine task, a user does not know exactly what to do. In this situation, the user may experiment within the interface by clicking on buttons either randomly or systematically to observe the effects. The user might guess at actions based on previous experience. He or she might also use a tutorial, a help system, or documentation. Success in these “weak methods” of dealing with a new situation can be helped or hindered through system design.

Supports problem-solving

Users employ problem-solving behavior when they do not know exactly what to do. This behavior can be described as a search through a problem space [Newell and Simon 1972]. When confronted with a new problem, people guess at solutions based on previous experience, try things at random to see what happens, or search for the desired effect.

For this discussion, we assume that the user understands the goal of the task (e.g., I would like to replace all occurrences of “bush” with “shrub”), but the user may have to search through the system’s available commands to achieve the desired outcome.

Measures of how well a system supports problem-solving include

- the time it takes to accomplish a novel task

- the number of incorrect paths the user takes while accomplishing a novel task

- the type of incorrect paths the user takes while accomplishing a novel task (e.g., paths that have unforeseen and permanent side effects or benign paths that change nothing but simply add to the problem-solving time)

the time necessary to recover from incorrect paths (Systems that support UNDO usually score well on this measure.)

In addition to reducing time spent on incorrect paths, well-designed systems may actually enhance users' problem-solving capabilities, further improving productivity.

Facilitates learning

Humans continuously learn as they perform tasks. Even in routine situations, humans continue to speed up with each repetition, eventually reaching a plateau where further improvements in performance become nearly imperceptible. In non-routine situations, people learn by receiving training, consulting instructions (using a help system, documentation, or asking a friend), by exploring the system, by applying previous experience to the new situation, and/or by reasoning based on what they know (or think they know) about a system. They may also learn by making a mistake, observing that the erroneous action does not produce the desired result, and by remembering not to perform this action again.

Measures of how well a system supports learning typically include

the number of times a task must be performed by a user before it is completed without error. (Often investigators include a repetition requirement to avoid the "luck" factor; for example, a user must perform a task n times without error.)

the time before a user fulfills the error-free repetition requirement (defined above)

incidental learning measures, in which a user first performs a task until some level of mastery is reached. The user then performs a different task that he or she has not practiced. The problem-solving and learning measures associated with this second task are measures of incidental learning.

1.3 Reduces the impact of user errors caused by lack of knowledge (mistakes)

In addition to the errors people make even when they know how to accomplish their tasks (slips, discussed above), people make errors when they do not know what to do in the current situation. In a typical scenario, a user does not understand that the current situation differs in important ways from previously encountered situations, and therefore he or she misapplies knowledge of procedures that have worked before.¹ Errors due to lack of knowledge are called mistakes.

¹ It is often difficult to distinguish a mistake from an exploratory problem-solving action. Typically, a mistake is when the user "knows" what to do and is wrong; while problem-solving is when the user doesn't know what to do and is trying to find the correct way. Therefore, the difference can only be detected through means other than the observation of actions – think-aloud protocols or interviews about what a person intended when taking an action, or his or her response when the action does not have the intended result (which indicates a mistake) typically allow observers to make this distinction. However, for architecture design, this distinction is not important; some users may be problem-solving and others making mistakes, but the architecture should support both.

Design cannot prevent all mistakes, but careful design can prevent some of them. For example, a typical technique to help prevent mistakes is to gray out inapplicable menu items. Since some mistakes will still occur, systems should also be designed to accommodate them.

Prevents mistakes

The following are typical measures of how well a system helps to prevent mistakes:

- the number of mistaken actions that a user could make while completing a task

- the type of mistakes the user could make while accomplishing a task (e.g., paths that have unforeseen and permanent side effects, or benign paths that change nothing)

(While these measures appear similar to those associated with problem-solving; that case focuses on how well the system guides the user back to the correct path. Preventing mistakes focuses on how well the system guides the user away from an incorrect path. The difference is subtle.)

Accommodates mistakes

Since mistakes will occur if the user has the freedom to stray from a correct path, the system should accommodate these errors. The most telling measures of such accommodation are

- the degree to which the system can be restored to the state prior to the mistake

- the time necessary to recover from mistakes (Systems that support UNDO usually score well on this measure.) This duration includes the time needed to restore all data and resources to the state before the error.

2 Reduces the Impact of System Errors

Systems will always operate with some degree of error. Networks will go down, power failures will occur, and applications will contend for resources and conflict. Design cannot prevent all system errors, but careful design can prevent some of them. All systems should be designed to tolerate system errors. This section differs from section 3.1. “Reduces the impact of routine user errors” only in the source of the error discussed. Here, we address system

error, not user error. The measures stay the same but the object of measurement becomes the system.

2.1 Prevents system errors

As with preventing mistakes, the measures associated with preventing system errors are the number and type of error that occur as a user performs a task.

2.2 Tolerates system errors

Since system errors *will* occur, systems should be set up to tolerate them. Again, as with accommodating mistakes, the most telling measures of error tolerance are

the degree to which the system state can be restored to the state before the error.

the time necessary to recover from errors. This duration includes the time needed to restore all data and resources to the system state before the error.

3 Increases user confidence and comfort

In the scenarios included in this category, the benefits do not involve users' efficiency, problem-solving processes, ability to learn, or propensity to make mistakes. The benefits do involve how they feel about the system; for some architectural decisions do facilitate or inhibit capabilities that increase user confidence and comfort, and this may be of value to an organization. Measures of confidence and comfort are more indirect than the time- and error-based metrics in the preceding categories, and typically involve questionnaires or interviews, or analysis of buying behavior (e.g., return customers and referrals).

Appendix III: Usability Supporting Architectural Pattern Template
 Bonnie E. John, Len Bass, Maribel Sanchez-Segura, and Rob J. Adams, Sept. 2004

Name: Usability Supporting Architectural Patterns must have suggestive names, which give an idea of the problem addressed and the solution in a word or two.			
Usability Context The context is divided into three parts: the situation (or general usability scenario), the conditions under which this situation is relevant, and the potential benefits to the users if the problem arising from this situation is solved.			
Situation: A brief description of the situation that makes this pattern useful from the user's viewpoint.			
Conditions: Any conditions concerning the situation constraining when the pattern is useful			
Potential Usability Benefits: A brief description of the benefits to the user if the solution is implemented. We use the usability benefit hierarchy taken from Bass & John to express these benefits.			
Problem The problem is expressed as the requirements arising from human desires and capabilities and the task versus the constraints deriving from the state of the software or the environment. These forces result in responsibilities that the software must fulfil to solve the problem. The responsibilities are part of the solution, but it is valuable to see how they arise. They are, therefore, presented here.			
Forces exerted by the environment and task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software system	Responsibilities of the general solution
This field describes the state of the environment and the task, which may include issues of task criticality or control, among others.	This field describes the human desires and needs, which may include issues of salience or control, among others.	This field describes the state of the software, which may include issues of resources and control, among others.	This field contains the responsibility of the software and an argument about why this responsibility is necessary given the user/task needs and/or the system/environment constraints.
Specific Solution The specific solution is situated in a partial design that reflects requirements that the designer believes are more important than cancel. The designer will make particular choices of overall architecture, MVC is one example, we need to present our table as an example of how the general solution is customised for the overall architecture.			
General responsibilities of the software	Forces exerted by previous design decisions	Allocation of responsibilities to specific components	Rationale
This field describes the general responsibilities of the software identified in the problem description.	This field describes the forces that come from design decisions taken independently of usability aspects but that influence the way in which these aspects must be designed.	This field describes the responsibilities of the software components involved in the design of the usability aspects.	Justification of how this allocation of responsibilities to specific modules satisfies the problem.
Components diagram of specific solution			
Sequence diagram of specific solution			
Deployment diagram of specific solution (if necessary)			

Appendix IV
Relationship of Forces to General Responsibilities for Cancelling Commands
Bonnie E. John, Len Bass, Maribel Sanchez-Segura, Rob Adams, Elsa Golden
19-Feb-2004

Forces exerted by the environment and task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software	Responsibilities that must be satisfied by any software design solution:
Networks are sometimes unresponsive.	Users slip or make mistakes, or explore commands and then change their minds, but do not want to wait for the command to complete.	Software is sometimes unresponsive	R1. Must provide a means to cancel a command
Sometimes changes in the environment require the system to terminate	Users have to communicate their intentions to the software through overt acts (e.g., finger movements)	Software has to receive an action from the user to do something	R2. Provide a button, menu item, keyboard shortcut and/or other means to cancel the active command.
No one can predict when the environment will change	No one can predict when the users will want to cancel commands		R3. Must always listen for the cancel command or R4. Must always gather information (state, resource usage, actions, etc.) that allow for recovery of the state of the system prior to the execution of the current command

	<p>User needs to know that the command was received within 150 msec, or they will try again.</p> <p>It can be assumed that a user is looking at a button as they click it. People can see changes in color in their fovea.</p> <p>People can see changes in intensity in their peripheral vision.</p>	<p>R5. Must acknowledge receipt of the cancellation command appropriately within 150 msec. The acknowledgement must be appropriate to the manner in which the command was issued.</p> <p>For example, if the user pressed a cancel button, changing the color of the button will be seen.</p> <p>If the user used a keyboard shortcut, flashing the menu that contains that command might be appropriate.</p>
<p>The task or environment has indicated that the command should stop (e.g., the OS has determined that there is not enough memory to continue)</p>	<p>User has communicated a desire for the command to stop</p>	<p>EITHER The command itself is responsive at the time of cancellation</p> <p>OR The command itself is not responsive at the time of cancellation</p> <p>R6. The command must respond by cancelling itself (I.e., it must fulfill Responsibilities R10 to R21 (e.g., an object-oriented system would have a cancel method in each object)</p> <p>R7. An active portion of the application must ask the infrastructure to cancel the command, or</p> <p>R8. The infrastructure itself must provide a means to request the cancellation of the application (e.g., task manager on Windows, force quit on MacOS)</p>

		<p>The command has invoked collaborating processes</p>	<p>R9. If either R7 or R8, then the infrastructure must have the ability to cancel the active command with whatever help is available from the active portion of the application (I.e., it must fulfill Responsibilities R10 to R21)</p> <p>R10. The collaborating processes have to be informed of the cancellation of the invoking command (these processes have their own responsibilities that they must perform in response to this information, possibly treat it as a cancellation.). The information given to collaborating processes may include the request for cancellation, the progress of cancellation, and/or the completion of cancellation.</p>
	<p>User wishes to operate the system as if their command had not been issued.</p>	<p>EITHER the system is capable of rolling back all changes to the state prior to execution of the command.</p> <p>OR the system is not capable of rolling back some of the changes made during the operation of the command prior to cancellation</p>	<p>R11. Restore the system back to its state prior to execution of the command.</p> <p>R12. Restore the system back to as close to the state prior to execution of the command as possible</p> <p>R13. Inform the user of the difference between the prior state and the restored state.</p>

<p>The system should remain stable over time (if there are resources not returned, it may lead to subsequent system crash, e.g., memory leak)</p>	<p>User wants the software to return to the pre-command state.</p>		<p>R14. All resources that can be freed must be freed</p>
	<p>Users need to know to what degree this desire was achieved (because it may effect what they do in their current or future tasks)</p>	<p>IF some resources has been irrevocably consumed and cannot be restored</p>	<p>R15. Inform the user of the partially-restored resources in a manner that they will see it.</p>
<p>For critical tasks, the inability to restore state or resources may require external actions to acknowledge the partial restore</p>	<p>Users may not always be paying attention, or may forget to take action</p>		<p>R16. Require acknowledgement from the user that they are aware of the partially-restored nature of the cancellation.</p>
<p>EITHER it is not critically important to the task that the cancellation be complete before another action can be taken</p>	<p>User wants to multi-task depending on the time it will take to cancel the command, typically more than 1 second.</p>	<p>The command takes more than 1 second to cancel</p>	<p>R17. Return control to the user, or not, depending on the forces from the task</p>
	<p>Users expect accurate feedback (within 20%, see TN) so they can plan their multitasking.</p>		<p>R18. If control cannot be returned to the user, inform the user of this fact (and ideally, why that is the case) R19. Estimate the time it will take to cancel within 20%</p>
<p>OR it is critically important to the task that the cancellation be complete before another action can be taken</p>			<p>R20. Inform the user of this estimate. If the estimate is between 1 and 10 seconds, changing the cursor shape is sufficient. If the estimate is more than 10 seconds, and time estimate is with 20%, then a progress indicator is better.</p>

			<p>If estimate is more than 10 seconds but cannot be estimated accurately, consider other alternatives (see TN, footnote 8)</p>
	<p>User wants to be notified when the cancellation has finished</p>		<p>R21. Once the cancellation has finished the system must provide feedback to the user that cancellation is finished, e.g., if cursor was changed to busy indicator, change it back to normal; if progress bar was displayed was displayed, remove it; if dialog box was provided, close it.</p>

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Usability Supporting Architectural Pattern (template)

<p>Name: Usability Supporting Architectural Patterns must have suggestive names, which give an idea of the problem addressed and the solution in a word or two.</p>		
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<p>Situation: A brief description of the situation that makes this pattern useful from the user's viewpoint.</p>		
<p>Conditions: Any conditions concerning the situation constraining when the pattern is useful</p>		
<p>Potential Usability Benefits: A brief description of the benefits to the user if the solution is implemented. We use the usability benefit hierarchy taken from Bass & John to express these benefits.</p>		
<p>Problem The problem is expressed as the requirements arising from human desires and capabilities and the task versus the constraints deriving from the state of the software or the environment. These forces result in responsibilities that the software must fulfil to solve the problem. The responsibilities are part of the solution, but it is valuable to see how they arise. They are, therefore, presented here.</p>		
<p>Forces exerted by the environment and task</p>	<p>Forces exerted by human desires and capabilities</p>	<p>Forces exerted by the state of the software system</p>
<p>This field describes the state of the environment and the task, which may include issues of task criticality or control, among others.</p>	<p>This field describes the human desires and needs, which may include issues of salience or control, among others.</p>	<p>This field describes the state of the software, which may include issues of resources and control, among others.</p>
		<p>Responsibilities of the general solution</p>
		<p>This field contains the responsibility of the software and an argument about why this responsibility is necessary given the user/task needs and/or the system/environment constraints.</p>

Specific Solution			
The specific solution is situated in a partial design that reflects requirements that the designer believes are more important than cancel. The designer will make particular choices of overall architecture, MVC is one example, we need to present our table as an example of how the general solution is customised for the overall architecture.			
General responsibilities of the software	Forces exerted by previous design decisions	Allocation of responsibilities to specific components	Rationale
This field describes the general responsibilities of the software identified in the problem description.	This field describes the forces that come from design decisions taken independently of usability aspects but that influence the way in which these aspects must be designed.	This field describes the responsibilities of the software components involved in the design of the usability aspects.	Justification of how this allocation of responsibilities to specific modules satisfies the problem.
Components diagram of specific solution			
Sequence diagram of specific solution			
Deployment diagram of specific solution (if necessary)			

Usability Supporting Architectural Pattern Observing System State

<p>Name: Observing system state</p>
<p>Usability Context</p>
<p>Situation: A user may not be presented with the system state data necessary to operate the system (e.g., uninformative error messages, no file size given for folders). Alternatively, the system state may be presented in a way that violates human tolerances (e.g., is presented too quickly for people to read. See: Working at the User's Pace). The system state may also be presented in an unclear fashion, thereby confusing the user. System designers should account for human needs and capabilities when deciding what aspects of system state to display and how to present them.</p> <p>Conditions of the Situation: A user is working in a system and wants to know about the progress of the task that is being executed.</p> <p>Potential Usability Benefits (TO THE USER):</p> <ul style="list-style-type: none"> A. <i>Increases individual user effectiveness</i> <ul style="list-style-type: none"> A.1 <i>Expedites routine performance</i> <ul style="list-style-type: none"> A.1.1 Accelerates error-free portion of routine performance A.1.2 Reduces the impact of routine user errors (slips): When the inevitable slip happens, if the system state is readily and easily observed, the user will know how to correct the slip before continuing further down an incorrect path. <ul style="list-style-type: none"> A.2 <i>Improves non-routine performance</i> A.2.1 Supports problem-solving: Human problem solving depends on knowledge of current state (where you are), the goal state (where you want to be), and awareness of the range of available actions. Thus, being able to observe the current system state is central to the process of problem solving. A.2.2 Facilitates learning: Learning correct actions depends on knowing the system state when the action produced a desired response. Thus, if the system state is obscured or unobservable, the user's ability to learn will be inhibited. A.3 <i>Reduces the impact of user errors caused by lack of knowledge (mistakes)</i> <ul style="list-style-type: none"> A.3.1 Prevents mistakes A.3.2 Accommodates mistakes: If the system state is readily and easily observed, the user will know how to correct the mistake before continuing further down an incorrect path. A.2.3 <i>Prevents system errors</i> B. <i>Reduces the impact of system errors</i> <ul style="list-style-type: none"> B.1 Prevents system errors B.2 Tolerates system errors C. Increases user confidence and comfort: <i>This applies to the special case of the user being unable to determine the level of security for data entered into a system. Such experiences may make the user hesitate to use the system or avoid it altogether. Thus, systems that prominently display security policies and security levels (both of which are features of system state) increase user confidence and comfort.</i>

Problem (see appendix for references)		General Responsibilities of the software:	
Forces exerted by the environment and task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software	
		<p>ST01: The artefact (SW application in this case) must display state information that is likely to change over time, especially if that state information represents many variables (e.g., status bar on windows applications; train, bus or airline schedule; VCR display....) [Tidwell, 99]</p> <p>ST02: When some change in system state occurs, the user should be notified. [Coram, 96]</p> <p>ST03: (In case of system failure) [Nielsen, 93]</p>	<p>R01: The software should be able to listen to active commands, because they can provide information about the state of the system. If this information is useful to the user, the system should be able to provide this information to the user in the appropriate manner and in the appropriate location, not only through the display.</p> <p>R02: As the system can fail, the software should be able to ascertain the state of active commands, because users should be informed if the command is not performing due to external circumstances.</p> <p>The system should be equipped with a mechanism by means of which it can check at any time whether a given command is being executed and, if the command fails, inform users that the command is not operational.</p>
ST03: (In case of system failure) [Nielsen, 93]		<p>C1: The system sometimes jams up because a given command does not respond; it then is important to alert users to the fact that this command has jammed.</p> <p>C2: The system gives a warning that a given resource, be it the network, a database, etc., is not operational.</p>	<p>R03: The software should be able to listen to or query external resources, like networks or databases, about their state, to inform the user if any resource is not performing properly.</p> <p>The system should be equipped with a mechanism by means of which it can ascertain at any time the state of given external resources, such as networks, databases, etc., so that it can inform users if any of these resources are not operational.</p>
		<p>C4: The system alerts users to the fact that they have to do a given previously programmed task.</p> <p>C5: The system alerts users to the fact that they should save what they are doing, as the system will switch off in 1 minute because the battery is low and users will lose everything that is open.</p>	<p>R04: The software should be able to check the state of the system resources and alert users in advance to save their work, because the system is running out of a given resource and will have to shut down.</p>

Problem (see appendix for references)			
Forces exerted by the environment and task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software	General Responsibilities of the software:
	<p>LA03: System tasks that take a long time (typically more than a few seconds) and must be completed before the next tasks can be started [Welte, 00]</p> <p>LA07: 10 seconds is about the limit for keeping the user's attention focused on the dialogue. For longer delays, users will want to perform other tasks while waiting for the computer to finish [Nielsen, 93]</p> <p>LA10: Provide continuous feedback about progress [Benson, 02]</p>	<p>LA01: A time-consuming process is going on, the results of which are of interest to the user [Tidwell, 99]</p> <p>LA02: Use a progress indicator when a time-consuming operation interrupts the UI for longer than 2 seconds or so show the animated indicator of how much [Tidwell, 02]</p>	<p>R05: For each action required by the users, the software must be able to calculate the elapsed time to finish each requested operation:</p> <p>1.If elapsed time is less than 2 seconds, then changing the cursor shape is sufficient.</p> <p>2.If elapsed time is more or equal to 2 seconds, then:</p> <p>? If the ongoing action is critical for the system or for the resources involved in the current action then:</p> <p>? Either: Show the progress, continuously (every 2 seconds, LA03), using progress indicator if the time estimate is within 20% (LA10). Give an indication of the time remaining, either as a figure, or graphically (as a time bar, as a clock...) OR: Show the progress, continuously (every 2 seconds, LA03), using progress indicator. If the time cannot be estimated accurately, consider other alternatives. (LA10). If timing cannot be estimated, but the process has identifiable phases, give an indication of the phases completed and of the phases remaining.</p> <p>? Do not return the control to the user</p> <p>? Notify the user when the task in progress has finished</p> <p>? Provide a Stop or Cancel button</p> <p>? If the ongoing action is not critical for the system or for the resources involved in the current action then:</p> <p>? Show the progress, continuously (every 2 seconds, LA03) (LD10)</p> <p>? Return the control to the user</p> <p>? Provide a Stop or Cancel button</p> <p>? Notify the user when the task in progress has finished</p>

Problem (see appendix for references)			General Responsibilities of the software:
Forces exerted by the environment and task	Forces exerted by human desires and capabilities	Forces exerted by the state of the software	
	<p>LA05: 0.1 second is about the limit for having the user feel that the system is reacting instantaneously [Nielsen, 93]</p> <p>IF01: People need to know that the system has registered an interaction event, such as mouse click, mouse movement, arrow movement, keyboard press, etc. (where an interaction event is only part of a sequence of commands to a system, or where no explicit user perceptible effect is achieved, people can become anxious that they have not been "heard" by the system, and may repeat the click or movement) [Brighton 98][Benson 02]</p>		<p>R06: In any case the software should be able to notify the user about the registration of an interaction event within 100 milliseconds.</p>
	<p>LA09: Systems should let users know how input from the users was interpreted. [Constantine, 99]</p> <p>IF01: People need to know that the system has registered an interaction event, such as mouse click, mouse movement, arrow movement, keyboard press, etc. (where an interaction event is only part of a sequence of commands to a system, or where no explicit user perceptible effect is achieved, people can become anxious that they have not been "heard" by the system, and may repeat the click or movement) [Brighton 98]</p>		<p>R07: The software should be able to show users how their required interaction has been interpreted.</p>
	<p>W01: The user may unintentionally cause a problem situation which needs to be solved [Welie, 03]</p>		<p>R08: The software must be provided with the ability to ask the user for confirmation if the user has requested an irreversible action.</p>

Specific Solution		Allocation of responsibilities to specific components	Rationale
<p>General Responsibilities of the software</p> <p>R07: The software should be able to show how their required interaction has been interpreted.</p>	<p>Forces that come from design decisions already made</p>	<p>Active command: The first time an active command is created by the controller (4) then the active command must create an instance of Resource checker (5) and an instance of System Resource Checker (6), both of them running in a different thread from active command.</p> <p>Feedbacker: Receives the information to be displayed from the active command. (1). And represents the appropriate feedback in each case to the user (EI02)</p> <p>Viewer: must provide a way to listen actions requested from the user (EI01)</p> <p>Controller: Should be listening to the Viewer (3) and if the user request some action creates the asked command, an instance of active command, (4).</p>	
<p>R01: The software should be able to listen to active commands, because they can provide information about the state of the system. If this information is useful to the user, the system</p>	<p>Model: The model should include an element that listens to active commands and, if the information is useful, sends the information to be passed on to the user (see model decomposition)</p> <p>View: Should be able to inform the user in the appropriate manner.</p>	<p>Active command: Represents the command in progress and should inform appropriate feedback if the user is to be notified of something (1).</p> <p>Feedbacker: Receives the information to be displayed from the model (1) or a change of view from the controller (2)</p>	<p>The active command should run in a different thread from the listener, because if the command in progress is dead, this event can be notified to the user through some other component.</p> <p>Separation of view and feedback allow the "feedbacker" component to specialise in messages and feedback for the user, and then the</p>

Comment: This has a very broad meaning

¹ These codes are used in the UML sequence diagrams as follow:

Numbers: interaction between classes

? EI: for external interaction

? ER: for external resources interaction

? IR: for internal resources interaction

? IP: for internal procedures

<p>should be able to provide this information to the user in the appropriate manner and location, not only through the display.</p>	<p>Controller: Should be listening to the Viewer (3) and if the user request some action creates the asked command, an instance of active command, gathering the user-to-system interactions. (4).</p>
<p>R02: As the system can fail, the software should be able to ascertain the state of active commands, because users should be informed if the command is not performing due to external circumstances.</p>	<p>Model: The model is in charge of checking that the command in progress is active.</p> <p>Resources checker: from time to time, it asks the active command whether it is alive (7); if there is no answer from the Active command, then the Resource Checker assumes that the command in progress is dead and selects the appropriate feedback to acknowledge the user of such event. (9)</p> <p>Feedback: Receives the information to be displayed from the Active command (1), from the Resource checker (9) or from the System resource checker (10). Also the controller can select the appropriate feedback (2).</p> <p>Controller: (nothing required)</p>
<p>R03: The software should be able to listen to or query external resources, like databases, networks, etc., about their state, to inform the user if any resource is not performing properly.</p>	<p>Resources checker: From time to time, it asks the external resources if they are alive (ER01); if there is no answer from the requested external resource, then the Resource Checker assumes the resource is not performing properly and informs the user through the appropriate feedback (9). If the resources are performing properly, they answer the Resource checker (ER02).</p> <p>Feedback: Receives the information to be displayed from the resource checker. (9)</p> <p>Controller: (nothing required)</p>
<p>R04: The software should be able to check the state of the system resources and alert users in advance to save their work, because the system is running out of a given resource and will have to shut down.</p>	<p>System Resource Checker: Should be able to check the system resources (R01) that the ongoing command is using; when they are under a specific limit, it should send a message to the appropriate feedback (10) to inform the user about what to do in this situation (probably close the application, save, etc.)</p> <p>Feedback: Receives the information to be displayed from the System Resource checker. (10)</p> <p>Controller: (nothing required)</p>

<p>R05: For each action required by the users, the software must be able to calculate the elapsed time to finish each requested operation:.....</p> <p>Model:</p>	<p>Active Command: Should be able to calculate the time taken to finish each requested operation (IP01), and to determine whether the ongoing command needs to be completed before any other task can be performed (IP02).</p> <p>1.If elapsed time is less than 2 seconds, then changing the cursor shape is sufficient.</p> <p>2.If elapsed time is more or equal to 2 seconds, then:</p> <p>? If the ongoing action is critical for the system or for the resources involved in the current action then:</p> <p>? Block the viewer so no request from the user can be accepted (11)</p> <p>? Recalculate the remaining time each 2 seconds (IP01), and provide feedback to the user.</p> <p>? Either: Show the progress, continuously (every 2 seconds), using progress indicator, if the time estimate is within 20%. Give an indication of the time remaining, either as a figure, or graphically (as a time bar, as a clock..)(1)</p> <p>? OR: Show the progress, continuously (every 2 seconds), using progress indicator. If the time cannot be estimated accurately, consider other alternatives. If timing cannot be estimated, but the process has identifiable phases, give an indication of the phases completed and of the phases remaining. (1)</p> <p>? Provide a Stop or Cancel button (1)</p> <p>? Notify the user when the task in progress has finished (Selects the appropriate feedback, 1)</p> <p>Feedback: Receives the information to be displayed from the active command. (1). Provides a stop or cancel button (E102)</p> <p>Viewer: When the viewer must not accept any request from the user the viewer is blocker from the active command (11)</p> <p>Controller: (nothing required)</p>
<p>R06: In any case the software should be able to notify the user about the registration of an interaction event within 100 milliseconds.</p> <p>Model:</p> <p>View:</p> <p>Controller:</p>	<p>In any case, the time between the view receiving the interaction from the user, sending this interaction to the controller, the controller notifying the model, the model answering the controller, and the controller selecting the appropriate view should be no more than 100 milliseconds.</p>

<p>R08: The software must be provided with the ability to ask the user for confirmation if the user has requested an irreversible action.</p>	<p>Model:</p> <p>The active command should be able to ascertain whether or not the requested action is irreversible. (IP03) If the requested action is irreversible, the ongoing Active command component should notify the user to confirm the requested operation by selecting the appropriate feedback (1)</p>
<p>View:</p>	<p>Receives the interaction from the user (E102) and sends this information to the controller (3).</p>
<p>Controller:</p>	<p>Receives an interaction from the view (3) and sends this information to the active command (12).</p>

Summary of interactions:

- 1: from active command to feedback to select the appropriate feedback
 - 2: from controller to feedback because can be communication between controller and feedback (type view) without intervention of the model
 - 3: from viewer to controller to send the user interaction requested
 - 4: from controller to active command to create the active command corresponding the interaction requested from the user
 - 5: from active command to resource checker to create it.
 - 6: from active command to system resource checker to create it.
 - 7: from resource checker to active command to ask whether the active command is alive or not.
 - 8: from active command to resource checker to indicate the active command is alive.
 - 9: from resource checker to feedback to select the appropriate feedback, indicating to the user the command in course is dead or some external resource is dead.
 - 10: from system resource checker to feedback to select the appropriate feedback, indicating there are not enough system resources to execute the command in course.
 - 11: from active command to viewer to indicate the viewer that no request from the user must be accepted until the command in course has finished.
 - 12: from controller to active command to indicate the selected option in the case the command in course have irreversible consequences and the user must be asked.
- E101: from user to viewer to request a command execution
E102: from feedback to user to give information

- IP01: an active command internal procedure to calculate the time to finish requested operation
- IP02: an active command internal procedure to determine the cricity of the ongoing command
- IP03: an active command internal procedure to determine whether or not the requested action is irreversible.
- ER01: from resource checker to external resources to know about their status
- ER02: from external resources to resource checker to answer in case everything is OK.
- IR01: a system resource checker procedure to know about the status of system resources.

Before creating the UML components model, we present in Figure 1, a first approach to this model using a general boxes and arrows model where also appear the actors both users and external resources.

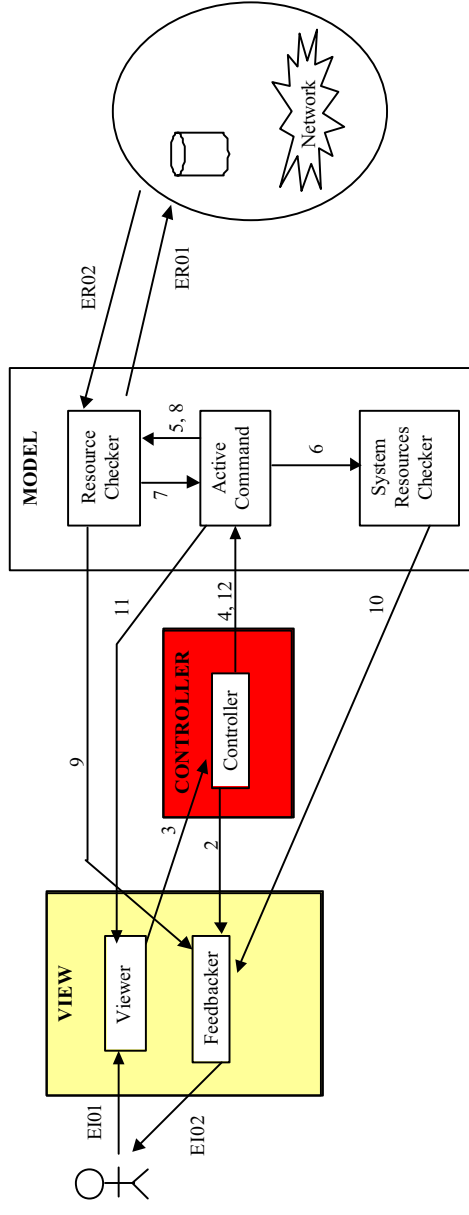
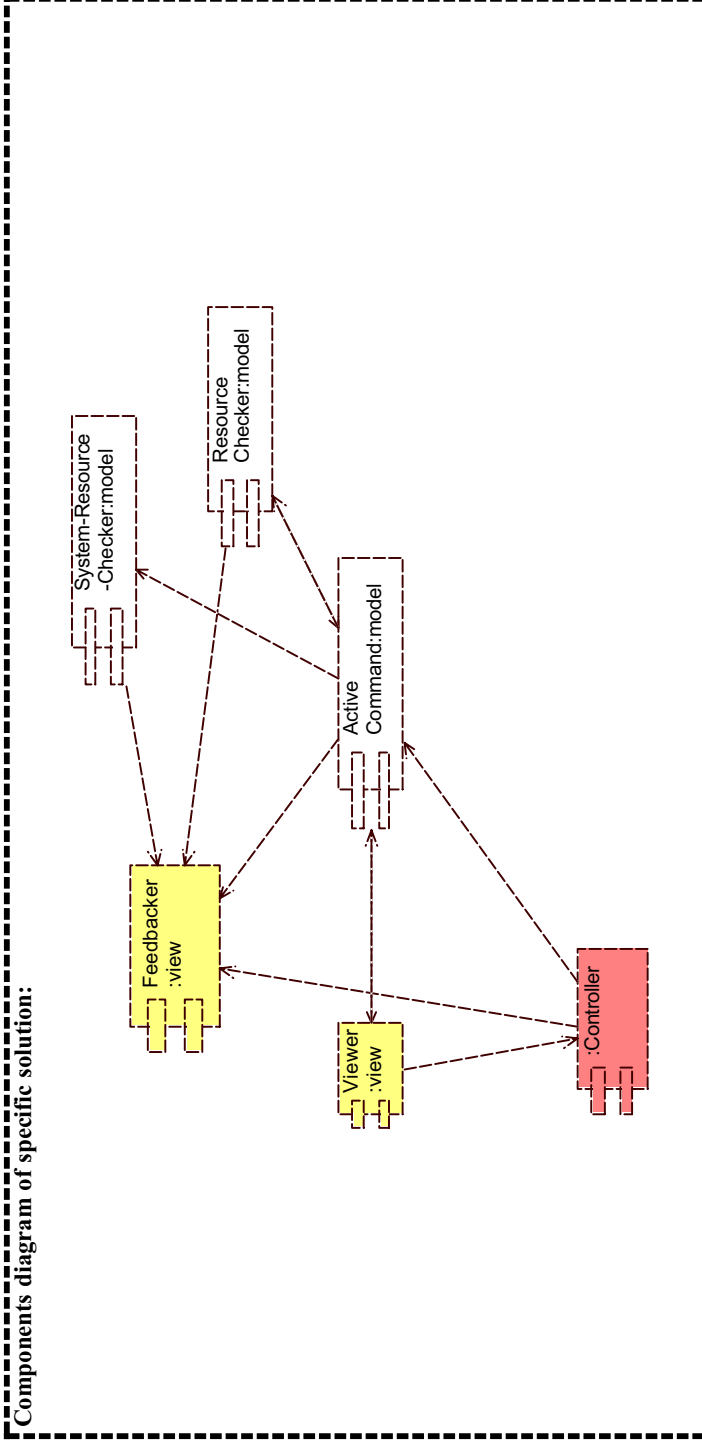


Figure 1 First approach to UML components model



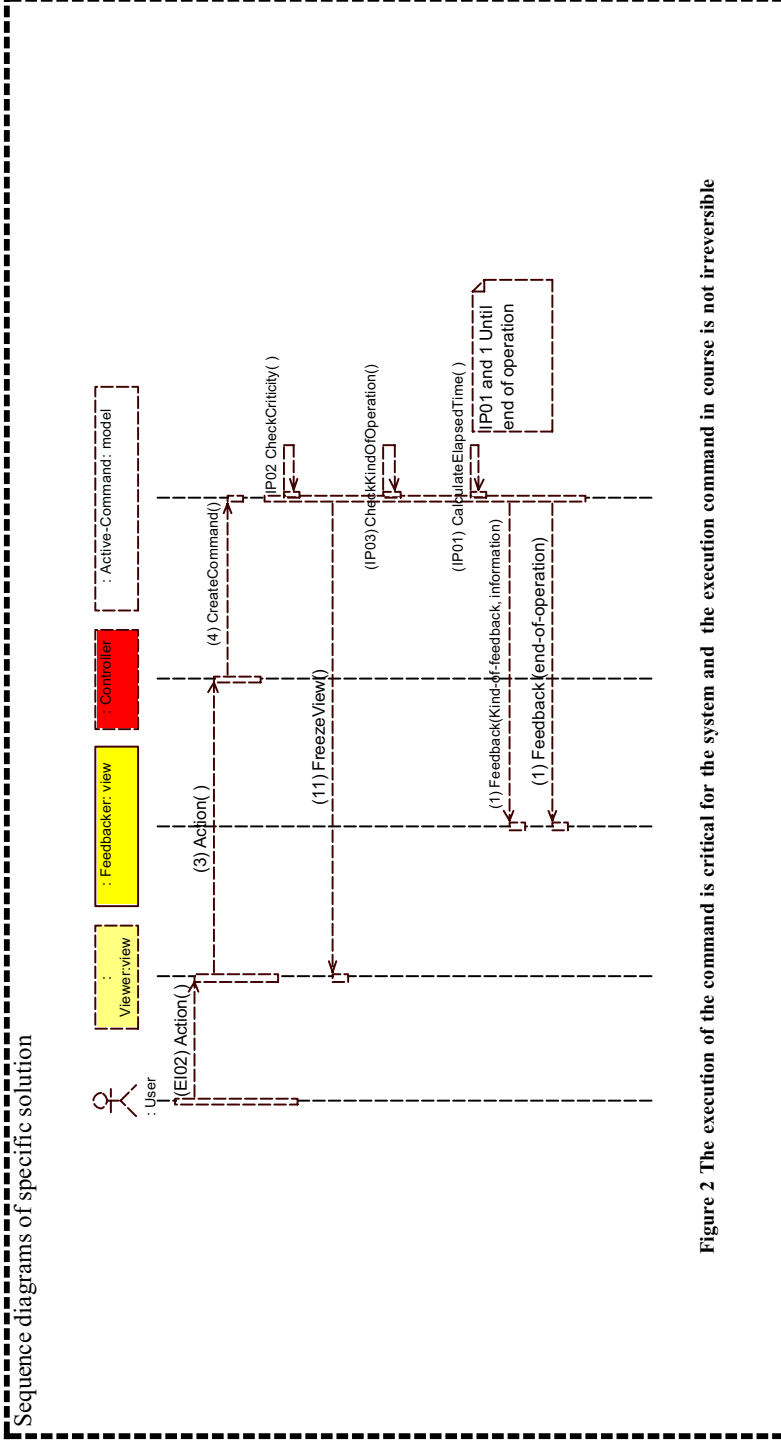


Figure 2 The execution of the command is critical for the system and the execution command in course is not irreversible

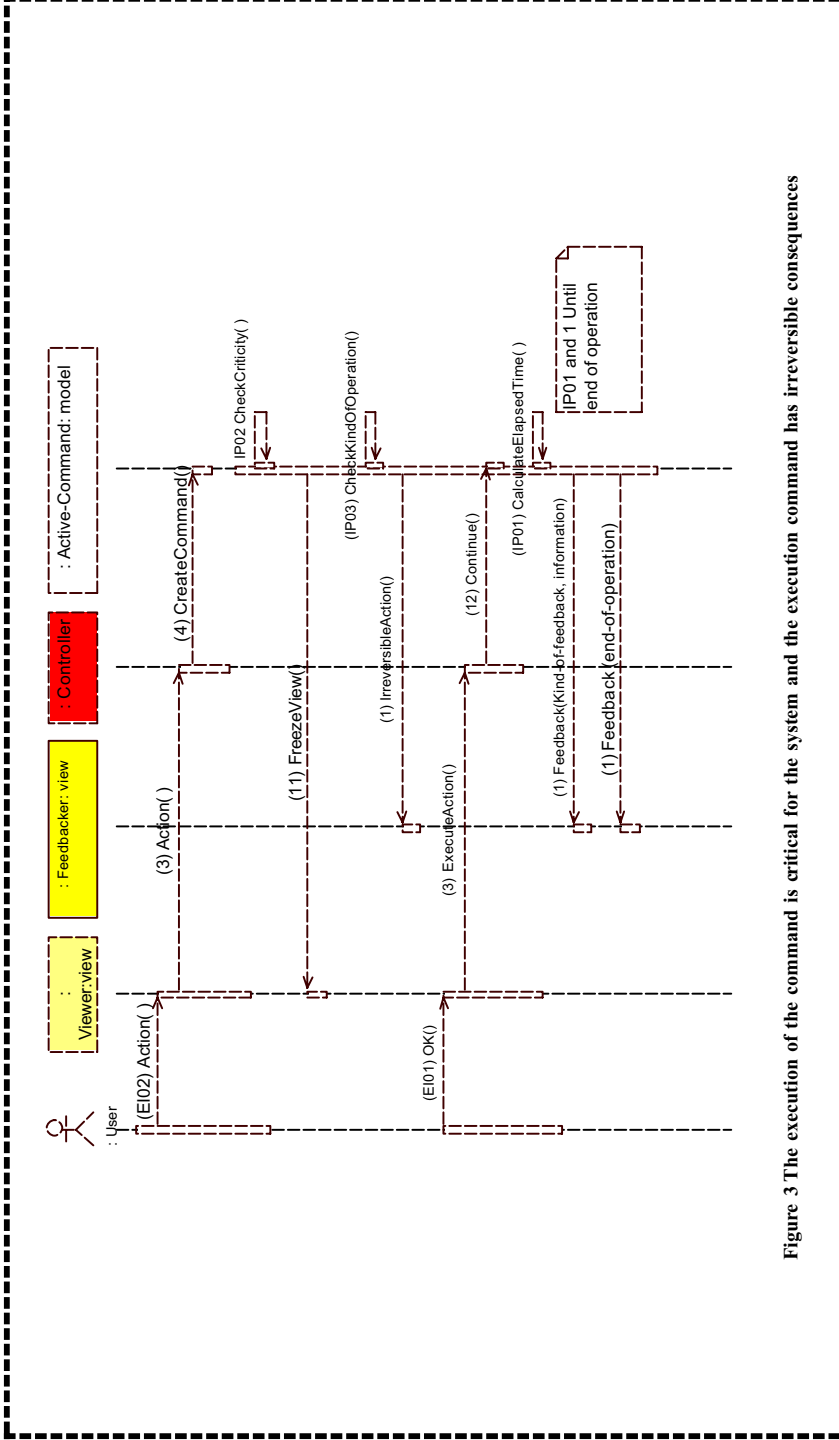


Figure 3 The execution of the command is critical for the system and the execution command has irreversible consequences

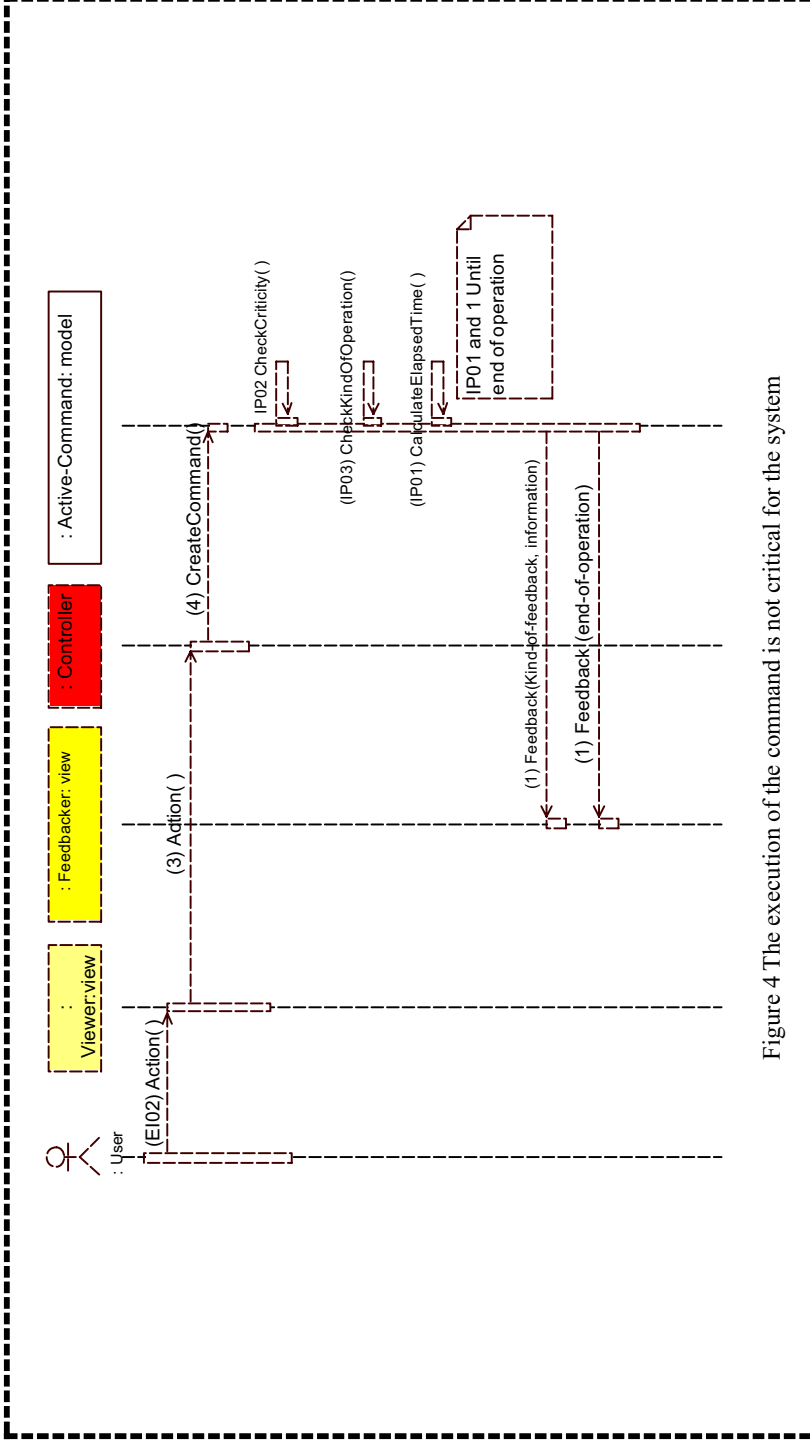


Figure 4 The execution of the command is not critical for the system

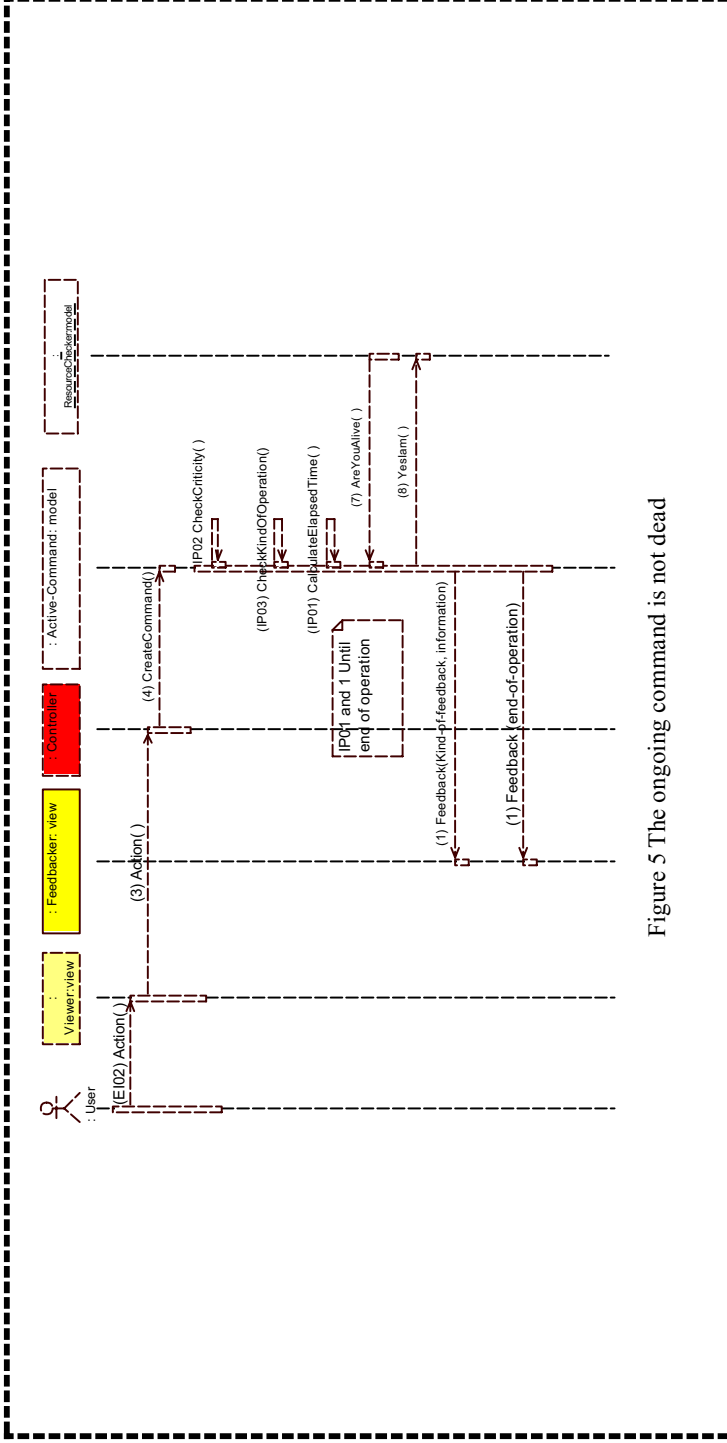


Figure 5 The ongoing command is not dead

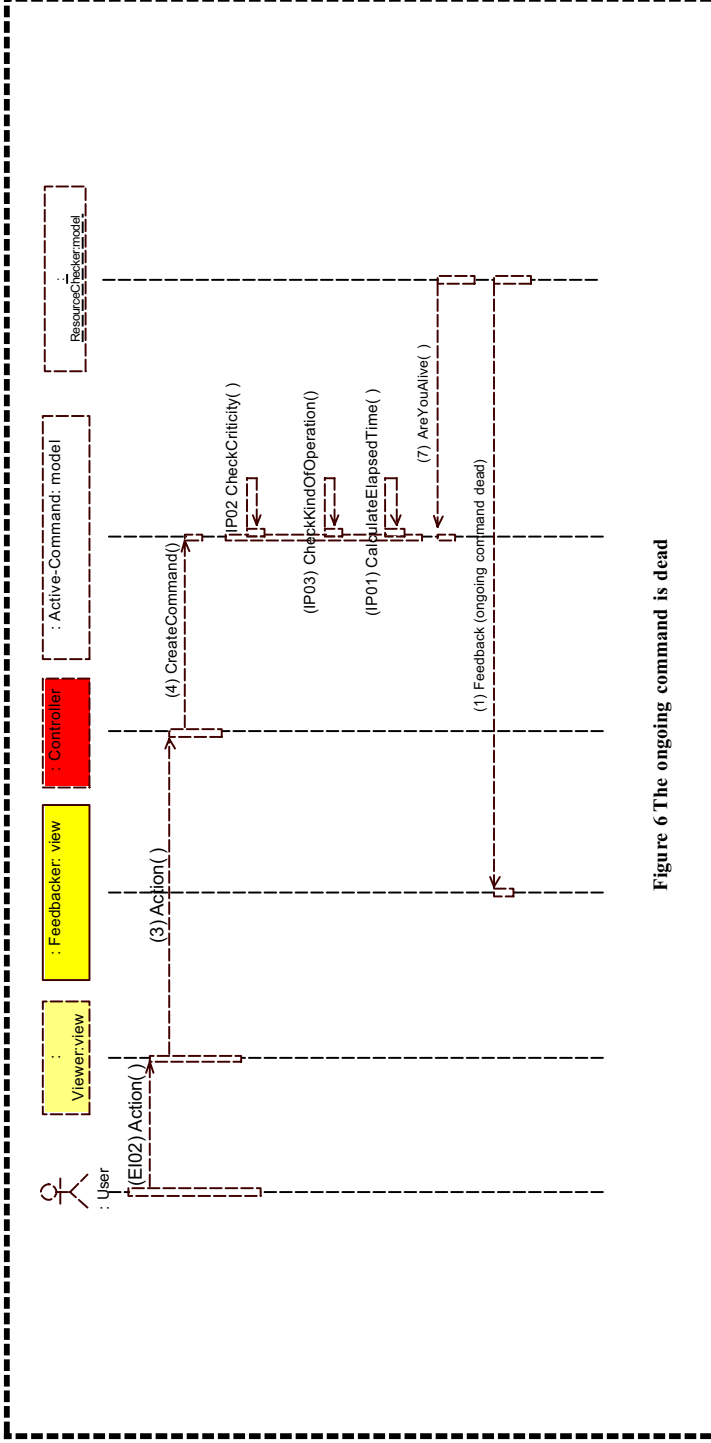


Figure 6 The ongoing command is dead

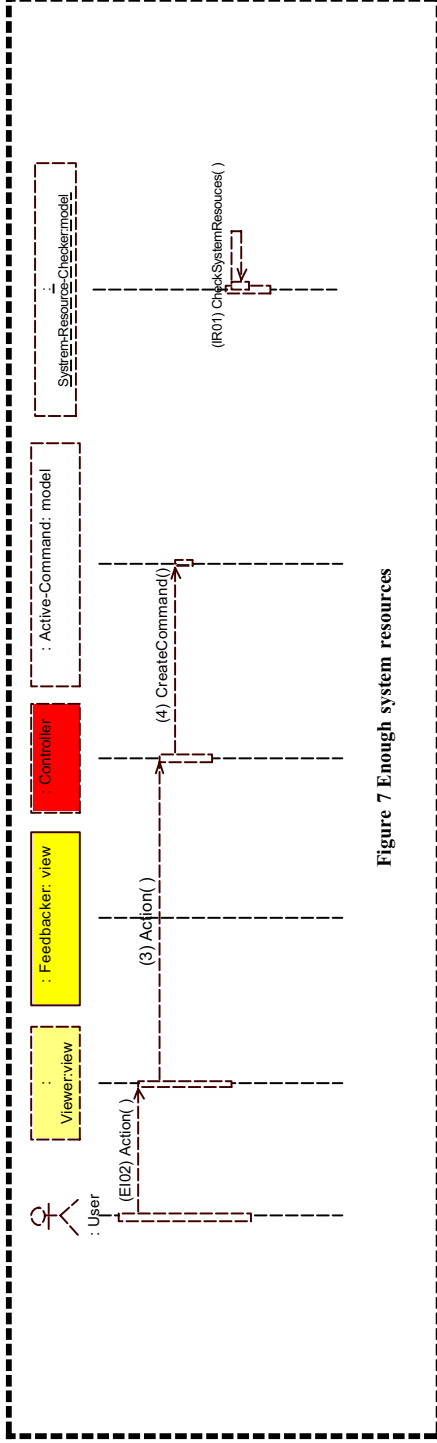


Figure 7 Enough system resources

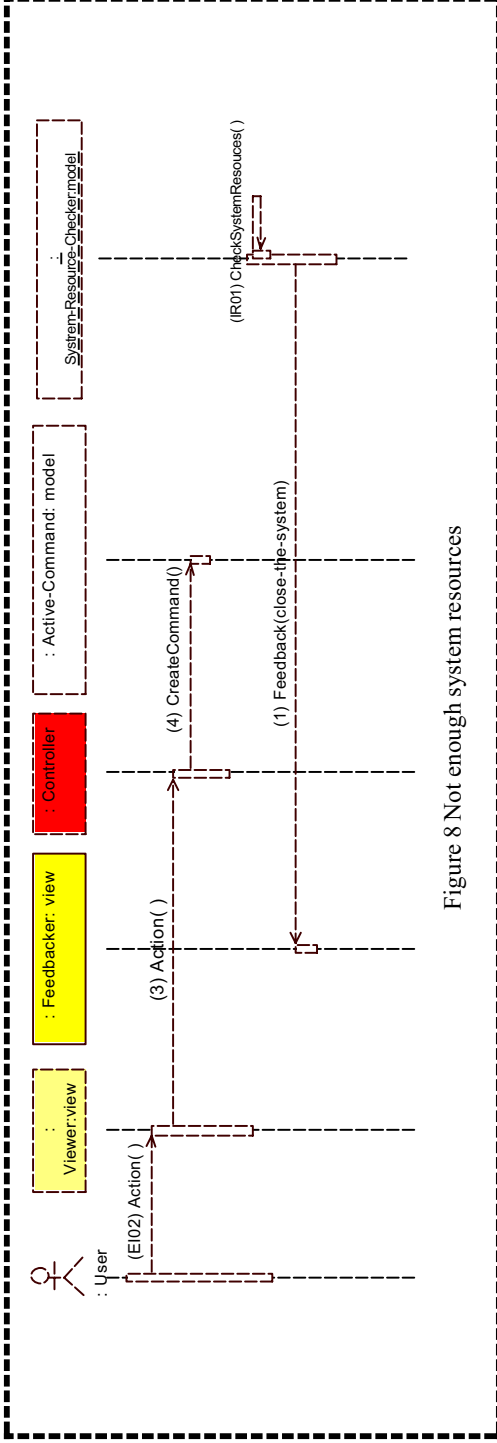


Figure 8 Not enough system resources

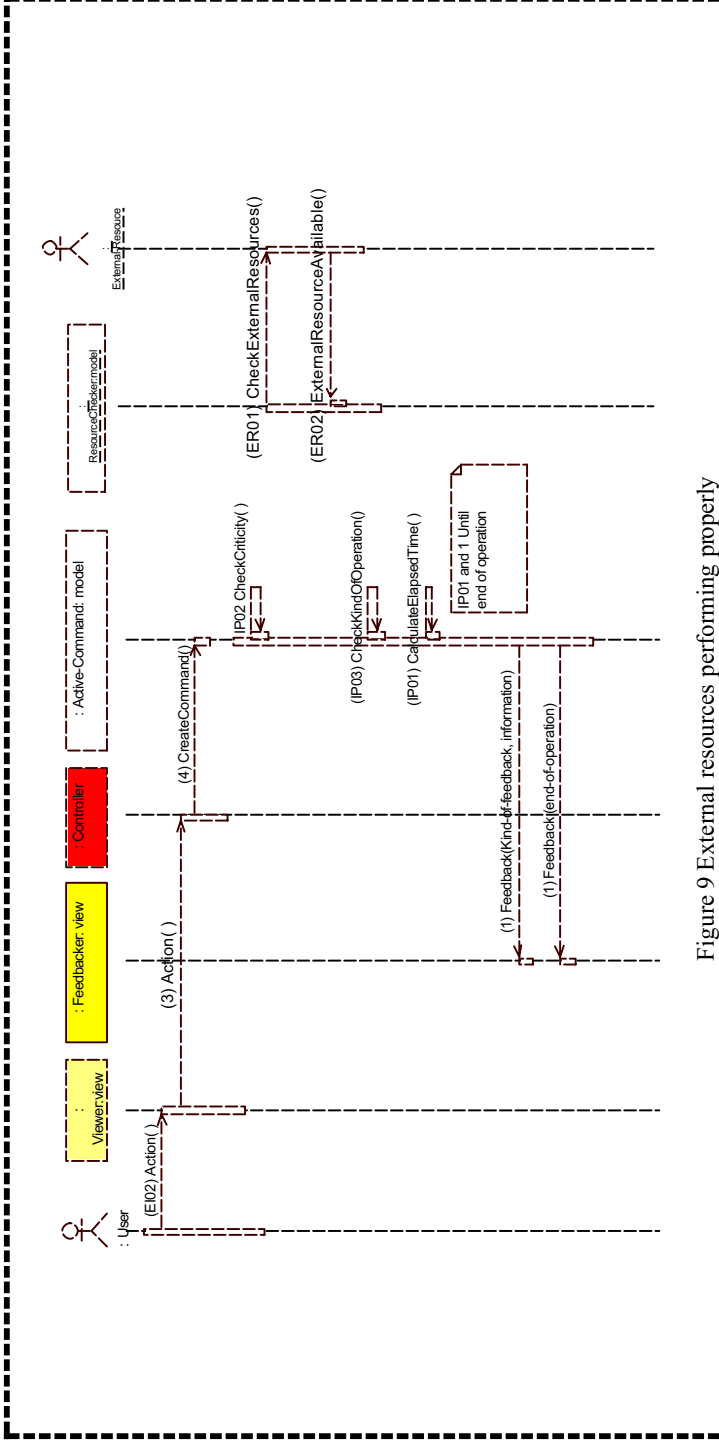


Figure 9 External resources performing properly

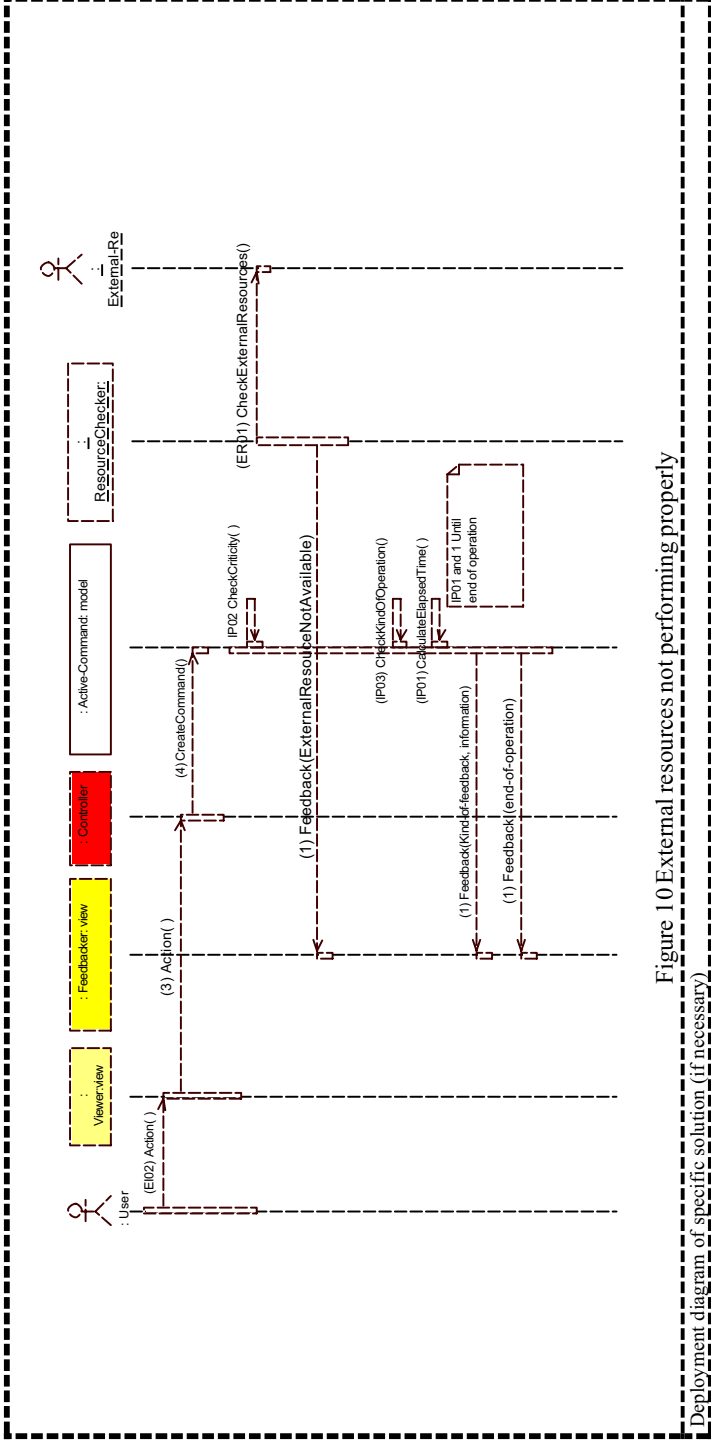


Figure 10 External resources not performing properly

Deployment diagram of specific solution (if necessary)

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APPENDIX

Experts in human-computer interaction, software system design or networks, who can give their view on the usability aspect in question, should be involved in this.

C1. The system sometimes jams up because a given command does not respond; it then is important to alert users to the fact that this command has jammed.

C2. The system gives a warning that a given resource, be it the network, a database, etc., is not operational.

C3. When a web agent finds something users are looking for on the web, it returns feedback to users or delivers a new e-mail, etc., that is, this point includes all the information that the system wants to supply to users, while the system is operating on other tasks.

C4. The system alerts users to the fact that they have to do a given previously programmed task.

C5. The system alerts users to the fact that they should save what they are doing, as the system will switch off in 1 minute because the battery is low and users will lose everything that is open.

C6. Users sometimes run several processes at the same time and want feedback to know that it finished.

C7. The system informs users how much longer it will take to complete a task, while allowing multitasking if the task in question can be performed at the same time as others. On the other hand, for example, when installing an operating system, users will only be informed of the progress of the task and will not be allowed to execute any other command in parallel.

C8. The system has to alert users to the fact that it has heard the interaction that they requested so that they not request the same service again because they think the system has not heard them.

C9. The system should warn users if they decide to invoke an action whose consequences are irreversible.

C10. The system, especially hypermedia navigational systems, should tell users where they are to assure that they do not get lost.

This section has been described according to the different types of feedback that have been identified in the literature.

System Status	Author	Usability Name	When	How
Usability Patterns	Tidwell 99	Status Display	ST01: The artefact (SW application in this case) must display state information that is likely to change over time, especially if that state information represents many variables (e.g., status bar on windows applications; train, bus or airline schedule; VCR display....)	Choose well-designed displays of the information to be shown and put them together in a way that emphasizes the important things, de-emphasises the trivial, doesn't hide or obscure anything, and prevents confusing one piece of information with another. Never rearrange it, unless the users do it themselves. Call attention to important information with bright colours, blinking or motion, sound or all three – but use a technique appropriate to the actual importance of the situation to the user. Use the positioning of an item within the Status Display to good effect; remember that people born into a European or American culture tend to read left-to-right, top-to-bottom, and that something in the upper left corner will be looked at most often.
	Coram 96	Modelling Feedback Area	ST02: When some change in system state occurs, the user should be notified.	Use a status area, rather than dialog boxes or pop-up windows, to display information about the current state of the application. Place it near the main display area, so that users can view this information when they deem appropriate (e.g., Word status bar or Netscape connection information in the bottom left-hand corner of the screen).
Web Usability Patterns				
Usability Heuristics	Nielsen 93	Feedback (In case of system failure)	ST03: (In case of system failure)	Systems can be designed for graceful degradation, enabling them to provide some feedback to users even when they are mostly down.
	Rubinstein 84 (referenced in Baeker 95)	Make states visible and visibly distinguished		
	Hix 93	Status Indicator		Give the user the appropriate status indicator
Web Usability Heuristics	Amgy 2003	Visibility of Web Site Status		

<i>Long Actions</i>	<i>Author</i>	<i>Usability Name</i>	<i>When</i>	<i>How</i>
Usability Patterns	Tidwell 99	Progress Indicator	LA01: A time-consuming process is going on, the results of which are of interest to the user	Show the user a status display of some kind, indicating how far along the process is in real time. If the expected end time is known or some other relevant quantity (such as the size of a file being downloaded) then always show what proportion of the process has been finished so far, so the user can estimate how much time is left. If no quantities are known – just that the process may take a while- then simply show some indicator that it's still going on. Animation is often used to good effect in this pattern. Motion draws the user's attention, and its cessation implies a new relaxed, stable state of being. Sound can also be used this way, for the same reason. Be subtle, though, and be aware of the importance of the process relative to the other things demanding the user's attention.
	Tidwell 02	Progress Indicator	LA02: Use when a time-consuming operation interrupts the UI for longer than two seconds or so	Show the animated indicator of how much progress has been made. Either verbally of graphically (or both), tell the user: ? ? what's currently going on ? ? what proportion of the operation is done so far, ? ? how much time remains, and ? ? how to stop it
	Welie 00	Progress	LA03: System tasks that take a long time (typically more than a few seconds) and must be completed before the next tasks can be started	Provide feedback at a rate that gives the user the impression that the operation is still being performed, e.g. every 2 seconds using animation. Additionally, provide a valid indication of progress. Progress is typically the time remaining until completion, the number of units processed or the percentage of work done. Progress can be shown using a widget such as a progress bar. The progress bar must have a label stating the relative progress or the unit in which it is measured.
	Welie 03	Progress	LA04: System tasks that take a long time (typically more than a few seconds) and must be completed before other successive tasks can start	Show that the application is still working and give an indication of the progress. Provide feedback at a rate that gives the user the impression that the operation is still being performed, e.g. every 2 seconds. Additionally, provide a valid indication of the progress. Progress represents typically the remaining time for completion, the number of units processed or the percentage of work done. The progress bar must state the relative progress or the unit in which it is measured.
	Brighton 98	Show Computer is Thinking	LA04V1: When an internal computer operation takes an indeterminate, but potentially substantial amount of time, people	Give feedback to the user that the system is basically functioning (by animated image driven by events generated in the process) and if possible indicate the stage of the process that has been reached.

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			may assume something has gone wrong	
		Time to Do Something Else	<p>LA04V2: When the computer is involved in a lengthy internal process users do not know if they have the opportunity to carry out another task or take a break</p>	<p>If the timing can be calculated, give an indication of the time remaining, either as a figure, or graphically (as a time bar, as a clock,...)</p> <p>If timing cannot be estimated, but the process has identifiable phases, give an indication of the phases completed, and of the phases remaining.</p> <p>If neither of these possibilities exists, then at least indicate the number of units processed (records, vectors ...)</p> <p>Use a status area, rather than dialog boxes or pop-up windows, to display information about the current state of the application. Place it near the main display area, so that users can view this information when they deem appropriate (e.g., Word status bar or Netscape connection information in the bottom left-hand corner of the screen).</p>
	Coram 96	Modelling Feedback Area	<p>LA04V3: The application must keep the user informed, especially when it is busy processing a request, or the user will become impatient and may think that the application has failed.</p>	
Usability Heuristics	Nielsen 93	Feedback	<p>Feedback becomes especially important if the system has long response times for certain operations. Basic advice regarding response times has been about the same for many years [Miller, 68, Card, 91]:</p> <ul style="list-style-type: none"> - 0.1 second is about the limit for having the user feel that the system is reacting instantaneously (LA05) - 1.0 second is about the limit for the user's flow of thought to stay uninterrupted, even though the user will notice the delay. (LA06) - 10 seconds is about the limit for keeping the user's attention 	<ul style="list-style-type: none"> - No special feedback is necessary, except to display the result - Normally, no special feedback is necessary during delays of more than 0.1 and less than 1.0, but the user does lose the feeling of operating directly on the data. - Users should be given feedback indicating when the computer expects to be done. Feedback during the delay is especially important if the response time is likely to be highly variable, since users will then not know what to expect.

<i>Long Actions</i>	<i>Author</i>	<i>Usability Name</i>	<i>When</i>	<i>How</i>
			focused on the dialogue. For longer delays, users will want to perform other tasks while waiting for the computer to finish (LA07)	
Shneiderman, 98		Informative feedback	LA08: Infrequent and major actions	- The response should be substantial - Visual presentation of the objects of interest provide a convenient environment for showing changes explicitly
Constantine, 99		Feedback Principle	LA09: Systems should let users know how input from the users was interpreted.	Aside from the spot on the screen where users work, users are most likely to attend to feedback at the centre or at the top of the screen, and are least likely to notice it at the bottom edge. The standard practice of putting information about changes of state on a status line at the bottom of a window is particularly unfortunate, especially if the style guide calls for lightweight type on a grey background (for example, word)
Benson 02		Feedback	LA10: Provide continuous feedback about progress	- Verify that your application provides feedback within 100 milliseconds after each key press, movement of the mouse, or other physical input from the user - Verify that your application takes no longer than 1 second to display each progress indicator. If a command might take longer than 5 seconds to complete its work on an object, allow users to interact with any parts of the object and parts of the application that are not directly affected by the command. If a command provides lengthy output, show partial results as they become available. Scroll the results if necessary until the user moves input focus to a component involved in the scrolling
Web Usability Heuristics	Angy 2003	Visibility of Web Site Status (e.g., credit card processing)	LA11: Your web site should always keep users informed about what is going on at any given moment	Description of feedback types : pointer, animation (progress bar) and when to use each one Example, let's say your e-commerce site is processing a credit card transaction. Your web site should inform the customer that the transaction is being processed. Most web sites do warn users that it may take 30-45 seconds to process their credit card, before they submit the order. I recommend that you take this one step further. For example, display an animated hourglass while the credit card is being processed.

<i>Interaction Feedback</i>	<i>Author</i>	<i>Usability Name</i>	<i>When</i>	<i>How</i>
Usability Patterns	Brighton 98	Interaction Feedback	<p>IF01: People need to know that the system has registered an interaction event, such as mouse click, mouse movement, arrow movement, keyboard press, etc. (where an interaction event is only part of a sequence of commands to a system, or where no explicit user perceptible effect is achieved, people can become anxious that they have not been "heard" by the system, and may repeat the click or movement)</p> <p>IF02: For every action the user takes, the system should provide some feedback that the program has accepted the command.</p> <p>IF03: Frequent and minor actions</p>	<p>This anxiety can be relieved by giving some feedback, proportional to the scale of the interaction event and its significance, to confirm to the user that the system has registered the event. Possibilities include indenting a button, backlighting a word, changing the shape of the cursor, making an audible click or beep.</p> <p>"Give visual feedback and allow the user to enable audio feedback for every interaction event".</p> <p>Use a status area, rather than dialog boxes or pop-up windows, to display information about the current state of the application. Place it near the main display area, so that users can view this information when they deem appropriate (e.g., Word status bar or Netscape connection information in the bottom left-hand corner of the screen).</p> <p>- The system response must be modest Visual presentation of the objects of interest provides a convenient environment for showing changes explicitly</p>
Usability Heuristics	Coram 96	Modelling Feedback Area		
	Shneiderman, 98	Informative feedback		
	Hix 93	Articulatory feedback	IF04:- To tell the user that the intended menu was the one selected	
		Semantic Feedback	IF04: That the intended menu was the <i>right</i> menu to choose for the task at hand	
	Heckel91 (referenced in Baeker 95)	Respond to the user's actions		
	Benson 02	Feedback	IF05: Acknowledge each user request	Verify that your application provides feedback within 100 milliseconds after each key press, movement of the mouse, or other physical input from the user

<i>Warnings</i>	Author	Usability Name	When	How
Usability Patterns	Welie 03	Warning	W01: The user may unintentionally cause a problem situation which needs to be solved	The warning should contain the following elements: A summary of the problem and the condition that has triggered the warning. A question asking the users if they intend to continue with the action or take other actions. Two main choices for the user, an affirmative and a choice to abort. The warning might also include a more detailed description of the situation to help the user make the right decision. The choices should be stated including a verb that refers to the action wanted. In some cases, there may be more than two choices. Increasing the number of choices may be acceptable in some cases, but strive to minimize the number of choices.
Usability Heuristics	Brighton 03	Think Twice	W02: A user may accidentally carry out an action that has serious consequences, such as deleting a file,	For each action that a user may take, having regard for: the reversibility of the action, the proportion of reversible actions that the system supports, the frequency with which the action is taken, the degree of damage that may be caused, and the immediacy of feedback, consider whether a warning, confirmation, authorization or automatic override may be appropriate
	Nielsen 93	Feedback (In case of user irreversible action)	W03: In case the user is going to perform an irreversible action	E.g. Overwrite files. Better feedback would include the name of the file, and the attributes of such files, such as file type and modification date.

You Are Here	Author	Name	When	How
Web Usability Patterns	Perzel, 99	You are Here		Provide users with information about their current location, allowing them to leave a trail to be able to return to that place quickly
	Matthews, 2003	Bread Crumbs	YAH01: Show the users where in a Web site they currently are	Typically found in the site's header, it tends to look something like this: Root >Foot>Bar>Page
		Visible Context	YAH02: In a web site with many cross-links, to help the reader know where they are in a web site	Include a small map or navigation bar on each page that links to pages near the current page. This might include pages that lead to the current page, pages related to the current page, and pages that give more detail about topics on the current page.

CATALOGUING INFORMATION

System status (ST): to inform users of the internal system state and state changes (including system failures)

- ? ST01: The artefact (SW application in this case) must display state information that is likely to change over time, especially if that state information represents variables (e.g., status bar on window application, train, bus or airline schedule, VCR displays...)
- ? ST02: When some change in system state occurs, the user should be notified.
- ? ST03: If the system fails, the user should be notified.

Long Actions (LA): to inform users that the system is processing an action that will take some time to complete.

- ? LA01: When a time-consuming process is going on, the results of which are of interest to the user, the user must be informed:
 - o If the on-going process is critical, users should not be allowed to do anything else until this task is completed. (LA03: System tasks that take a long time (typically more than a few seconds) and must be completed before the next tasks can be started,
 - o LA07: If the on-going task is not critical and takes over 10 seconds, users should be allowed to run another operation if they so wish. Users should be informed when the on-going operation finishes.
- ? LA02: Use when a time-consuming operation interrupts the UI for longer than two seconds or so.
- ? LA04: is equivalent to LA03
- ? LA04V1: is equivalent to LA01
- ? LA04V2: is equivalent to LA01
- ? LA04V3: redundant
- ? LA05: The system response to user actions should arrive with at the latest 0.1 second after user interaction.
- ? LA06: redundant
- ? LA08: redundant
- ? LA09: Systems should let users know how input from the users was interpreted.
- ? LA10: The software must provide continuous feedback about progress.
- ? LA11: For web systems, the web site should always keep users informed about what is going on at any given moment.

LA11, has been ignored because represents a specific kind of software systems, while the solution for the USAP must be a general solution.

Interaction Feedback (IF): to inform users that the system has registered user interaction, that is, that the system has heard users.

- ? IF01: The feedback must be provided within 100 ms.
- ? IF02: is equivalent to IF01

? IF03: redundant

? IF04: This feedback is covered in the error or critical cases, because it does not make sense to provide this type of feedback in all cases.

? IF05: is equivalent to IF01

Warning (W): To inform users of any irreversible action.

? W01: The system must be provided with the ability to ask the user before executing the irreversible action.

? W02: is equivalent to W01

? W03: is equivalent to W01

You are here (YAH): to inform users where they are in the application (mainly for web sites).

? YAH01: In a web site with many cross-links, a feedback procedure must be developed to help users to know where they currently are.

? YAH02: is equivalent to YAH01

These two cases have been ignored because they are referred to a specific kind of software system while the solution for the USAP should be independent of the kind of software to be developed.