User Interface Design, Development Tools, Advanced Prototyping

Software Engineering

CS577b 2001

Definition of “user interface”

- Simply, a *user interface (UI)* is any point of interaction between a human being and a computing device.
- UI design (particularly of graphical UIs, or GUIs) is a black art; it requires knowledge of the human users and the computer components the UI will be hiding.
- The *user* in UI is the person (or people, a *user base*) who will use a system. Knowing the user is critical to UI design: a UI can’t be everything to everybody, but doesn’t usually need to be.

Know your user, 1

- Humans are pretty diverse. Differences in users that affect UI design:
  - Physical differences: not everyone can see, hear, or type.
  - Cognitive and perceptual differences: two people of the same intelligence may think differently.
  - Personality.
  - Culture: cultural associations with names, shapes and colors vary widely.
  - Age: age is highly correlated with interests and abilities.

Know your user, 2

- Computer (particularly, GUI) skill varies widely.
  - Novice users need integrated help and prompts, and simple displays.
  - Intermediate, knowledgeable users need access to help, but also to shortcuts and customization.
  - Expert users need highly customizable interfaces, and may be happier with a simple, powerful, command-based (textual) interface.
- We can make a UI broadly useful to users via customization. (For fun, compare the extent customization possible in Microsoft Windows and X-windows (pick a window manager): which is more customizable? Which is “easier to use”?)

Types of UIs

- There are three main classes of UI:
  - Graphical (GUI): visual elements are manipulated with a pointing device.
  - Textual (CLI, command-line interface): commands are typed in, results are printed text.
  - Application Programming Interface (API): access internal functionality of a product through native languages, OS, protocols, etc.
- There are many types of UI:
  - Direct manipulation (GUI):
    - Virtual environments (usually 3d).
    - Drawing programs.
  - Form fill-in (web).
  - Command language (CLI), Programming language interface (PLI).
  - Natural language (not yet implemented).
- While most UIs rely on sight, they may be augmented or replaced with sound (beeps, text-to-speech), and touch (Braille printers).

Application areas that affect UI design

- Knowing the computer (the application underlying the UI) can be as important as knowing the user:
  - Industrial application UIs may be very specific (gauge reading).
  - Life critical systems (medical equipment, missile targeting, the Big Red Button) have low tolerance for mistakes.
  - Office applications should be “professional”.
  - Home applications should be “friendly”.
  - Entertainment application UIs may favor look over function.

UI metrics, 1

- UIs can be evaluated quantitatively, believe it or not. We can get a gang of potential users together, and measure:
  - Time (and effort) to learn (how long does it take to perform a new task?).
  - Speed of performance (how efficiently can I perform a task?).
  - Error rate in performing a task, or mixed tasks.
  - Retention (how well do users remember a task, once learned?).
- Often, though, we rely on "subjective satisfaction": how many of the users "like" the UI.

UI metrics, 2

- If you want to be very wanky, there is math for measuring the "goodness" of a UI (some at least):
  - Index of difficulty = Log_2 (2D / W)
    - D = distance to move the pointing device
    - W = width of target
  - Time to point = $C_1 + C_2$ * (Index of difficulty)
    - C_1 , C_2 = Device specific constants

("Time to point" is a measure of the effort needed to point a mouse at a screen object. A "device specific constant" might be the mouse sensitivity.)

Human aspects of UI design, 1

- Fun experiment here!

(Via flashing various slides containing collections of shapes, the presenter proves, at least qualitatively the truth of various assertions on the next slide. This fun, interactive recitation feature is enjoyed by all.)

Human aspects of UI design, 2

- From psychology, we know that:
  - Users can recognize 7 “chunks” of information at a time. That is, the eye can easily count up to 7, then gets confused. A “chunk” of information is often a logical division (think page layout).
  - These can be kept in memory for 15 to 30 seconds
  - Familiar information is grouped into a chunk: the mind can quickly aggregate related, familiar things and deal with them as a group.
  - Recognized or routine information may not count as one of the seven: the eye/mind can ignore things it understands in favor of things that are new.
- In particular, understanding these rules of how people work will help us create effective page layouts and display sequences.

‘Golden Rules’ of UI Design

- Features of a good UI:
  - Consistency: colors, names, icons and other associations are applied consistently.
  - Shortcuts increase efficiency for experienced users, without reducing learning time for novices.
  - Informative feedback: results, acknowledgements and errors should be specific and useful.
  - Dialogs should yield closure: when a user answers a question, the answer should be used immediately, and remembered.
  - Error prevention: confirmation dialogues should protect against costly mistakes.
  - Reversal of actions: multiple undo.
  - Feeling of control: the user should have the initiative, and shouldn’t have to follow directions from the computer.
  - Reduce short term memory load.

Specific UI tips, 1

- Make error messages:
  - Specific.
  - Constructive.
  - Positive.
  - User centered:
    - Second person phrasing.
    - Polite.
    - Informative.
- Bad error messages:
  - The Blue Screen of Death.
  - “Segmentation fault (core dumped).”
  - “I’m sorry, Dave, I’m afraid I can’t do that.”

Specific UI tips, 2

- Design:
  - Clutter (visual “noise”) slows the eye and frustrates the mind.
  - Inconsistency inhibits performance.
  - Avoid presenting the computer as a person.
  - Use short, simple sentences.
  - Don’t require a user to unnecessarily manipulate data:
    - A user shouldn’t have to convert units.
    - A user shouldn’t have to type anything twice.
    - A user shouldn’t have to remember information across screens.
  - Use logical divisions to organize many information units into a hierarchy, with < 7 units at a level.

Specific UI tips, 3

- Color:
  - Limit the number of colors that are associated with a meaning (ie, red means stop).
  - Recognize the power of a color coding scheme.
  - Place color coding under user control.
  - Certain colors have predefined meanings to different users (particularly across cultures).
  - Color fidelity and quality vary between platforms.
- Color examples:
  - If you are reading this in color, you'll agree that it's ugly.
  - In IBM's new Websphere application server product, a stopped service's icon is red, and running service is blue, not green. Apparently IBM found that green didn't mean anything to their Asian customers.

The ‘M’ in MRS

- How can you make UI requirements (SSRD) ‘measurable’?
  - Subjective measures:
    - Does the customer like it?
    - Do the eventual users like it?
  - Task-based experiments:
    - How long does it take a user to do task x?
    - How long to learn task x?
    - After learning x, if a user does x 17 times, how many errors do they make?
  - Design rationales: say why a specific UI feature is compatible with the needs of the users and/or application.
    - “The Missile Administrator user will have to press ‘Ok’ 5 times and enter his/her password twice before a missile will actually be fired.”
  - Etc… (be creative!)

Some examples…

- Web pages are interfaces too, and it's easy to find examples of bad ones.
- Try to say for each of the next examples whether the page is easy to use, or not; attractive, or not; "good", or not.
- In particular, think about colors, layout of independent regions, layout of text, and your general first impression. How quickly can you find what you want on the page?

Example URLs

- The next few pictures can be found at these URLS:
  - http://www.geocities.com/~tmfrench/cafemain.htm
  - http://www.motherboardsdirect.com/
  - http://www.ny.com/
  - http://www.wired.com/news/
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  - http://my.netscape.com/
  - http://www.methodfive.com/
- The pictures are for backup, it's better to actually go to the pages.

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Don't forget to check out our club info and the many original articles we've published in the past. (They're all listed below)
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(1) to organize aquarium enthusiasts in and around central Ohio
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Red Hat Gets New CEO
Posted by CmdrTaco on Monday November 15, @03:49PM
from the moving-on-up dept.
xjamie writes "Red Hat has more changes under their hat. CNet is running a story saying Matthew Szulik will replace Bob Young as Red Hat's CEO." So we went and bothered Bob at the LinuxToday booth. The deal is that he is going to be the Chairman, and focus more on the Open Source aspects of the business, and Matthew is gonna be more concerned with the next quarter's bottom line.
(Read More... | 28 of 38 comments)
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Slashdot's parent Andover.Net Files for IPO.
The latest installment of Geeks in Space is up at The Sync. Listen to CmdrTaco, Hemos, and Nate talk about the latest events to happen - or not happen in the computer world.
Perhaps you are seeking Jon Katz's series of articles related to recent events in Colorado. These articles include Voices from the Hellmouth, More Stories from the Hellmouth or The Price of Being Different,
With all the hype about the recent MindCraft Linux/NT benchmarks, you might be interested in reading ESR's Response to the Mindcraft Fiasco
For something different, try reading my little essay Thoughts from the Furnace about the internet, and flame.
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Paul Vixie to Leave BIND
Posted by Hemos on Monday November 15, @03:10PM
from the stepping-down-and-out dept.
strabo writes "Paul Vixie made it known at LISA '99 in Seattle on Wednesday that he'll be stepping down as the maintainer and head architect of BIND, which he has been doing for the past 10 years. Many thanks to Paul for his hard work and dedication!"
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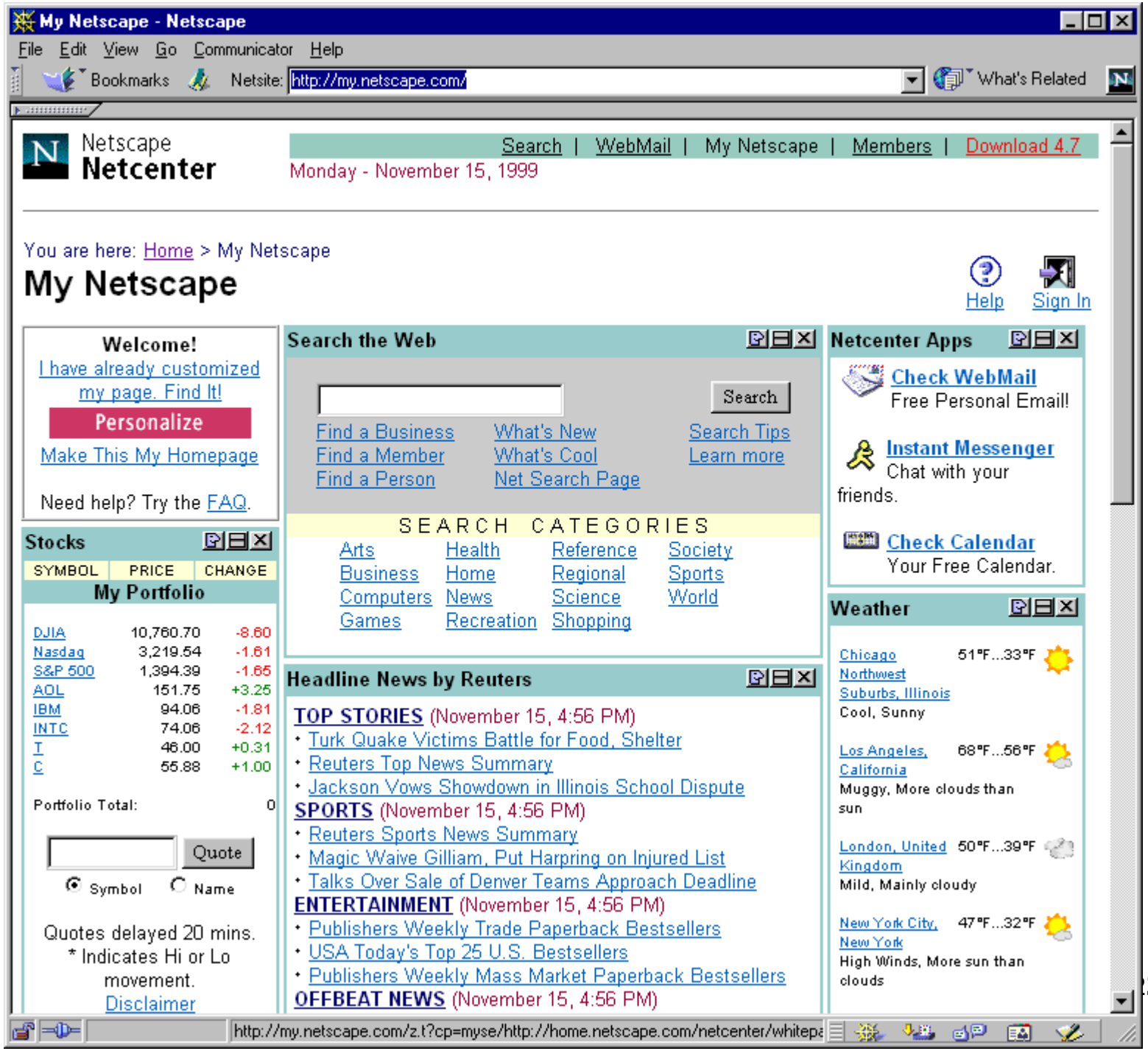
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Lessons learned (from web pages)

- From the previous slides, we can gather some insight on UIs:
  - Clean, spare, simple, concise: the four pillars of effective layout.
  - ‘Just say no’ to background images.
  - More information (whether text or buttons and menus) per unit area increases clutter, confusion.
  - Where information is dense, use visual modularizations to organize information.

An exercise…

- Create an interface with 3 option buttons, 3 menus, 2 action buttons, a text input, a large graphics area and various appropriate labels.
- Lay out this interface in the ugliest way you can imagine.
- Then, lay it out in a nice, efficient way.

Pretty fun, huh?

Development Tools, Advanced Prototyping

Prototyping

- Contents:
  - Goals of prototyping.
  - Types of prototype.
  - What should you have for LCO?
  - Prototyping guidelines.
  - To reuse to throw away?
  - Rapid prototyping tools.
  - How to choose a tool?
  - Scenarios.

Prototyping goals, 1

- Prototypes help with your customer negotiations:
  - Reality check: are you building what the customer expected?
  - A prototype gets you past “I’ll know it when I see it.”
  - Makes your project concrete for the customer.
  - Focuses negotiations on user concerns (when the customer isn’t the end user).

Prototyping goals, 2

- Prototypes help you design your product:
  - Any gaps or inconsistencies in the design/requirements may be revealed.
  - Questionable or difficult aspects can be tried out.
  - Outright errors in your initial design may show up.
  - Weaknesses in the development team's skills may be revealed (in time to get training).
  - Unanticipated problems with implementation technologies may be revealed (in time to try something else).
  - More important or more difficult requirements or components show up; knowing about these things helps with making a reasonable schedule and division of labor.

Types of prototype, 1

- Prototypes may be classified as:
  - Non-functional (for “look and feel”):
    - Images.
    - Static interface (in some language).
    - Example interaction (series of slides, or a log or journal file).
  - Functional (in various degrees):
    - Anything that runs and shows off some system features.
- Prototypes may be classified as corresponding to phases in the development, from “Initial” to “Pre-alpha”.*

* “Alpha” and “Beta” are industry parlance for pre-release software. An Alpha release includes major features, but isn’t intended for general use. A beta release should be mostly complete, but still needs testing.

Types of prototype, 2

- Prototypes may be classified by their intended use:
  - A prototype might be used to demonstrate the user interface, rather than the program's function.
  - A prototype might be used to demonstrate a programs function (in this case the UI is less important).
  - Any test program written to "try out" a technology or design aspect is a prototype. Prototypes may exist only to help the development team, rather than to show to the world.

Prototyping guidelines (construction and presentation)

- Create (and demonstrate) your prototype from the point of view of the user: the prototype should give an idea of what the real system will be like, for the user.
- Focus on the main points first!
  - What is the normal or most common user mode?
  - What will the most common user activity be?
  - What are the most important (core) features?
  - What are contentious issues/features among the development team, and with the customer?
  - What features will be difficult?
  - Leave optional, subtle or boring features for later.

To reuse or to throw away?

- A key decision with a prototype is whether to try to make it reusable (such that it can be a basis for the construction of the final product), or whether to plan to throw it away. Consideration include:
  - Can you (or do you want to) do the prototype in the final implementation language?
  - How much time do you have for this prototype?
  - Are you planning multiple prototypes?
  - What is the goal for the prototype (UI, user behaviors, technological feasibility)?
- Why would you throw away a prototype?
  - In doing the prototype, the design or requirements change substantially.
  - Prototyping with an easy, fast tool lets you get on to the good parts.
  - Prototyping lets you try things easily, which may be difficult in the final implementation.

Rapid prototyping tools

- "Rapid prototyping tools" are languages or programs that let you create prototypes more quickly than you could in your project's real implementation language/technology.
- The languages/programs listed here may be prototyping tools for one project, but final implementation tools for another.
- Prototyping tools include (but are not limited to):
  - Pencil and paper.
  - Images (Photoshop).
  - Static web pages (HTML and images).
  - Dynamic web pages (Javascript and CGI).
  - Scripting languages (Perl, Python, Tcl).
  - "Visual" programming environments (MS Visual Basic).
  - Database development tools (MS Access).
  - A "real" but "nice" language like Java (with AWT or Swing).

Tools: Static web pages

- Web pages are provide a common, familiar look, and basic set of functions.
- May be used to demonstrate user input forms.
- May easily be made colorful and attractive.
- May be created in various visual editors (Netscape Composer, MS FrontPage, Adobe PageMill).
- Can be accessed almost anywhere, from any nearly any type of (networked) computer.
- May be easily augmented with a certain amount of functionality.
- Disadvantages:
  - Relatively static interface; the display is constrained to “pages”.
  - Input widgets are limited (relative to VB, for instance).
  - Layout varies across platforms.

Tools: Dynamic web pages

- Javascript can add considerable function to a web page:
  - Error and confirmation dialogues.
  - Simple processing (arithmetic).
  - Modifications to the display (eg, cycling an image).
- Frames can implement multi-window displays (eg, a “tool bar” and a “work area”).
- Server-side CGI can be used to implement complex processing (eg, database interaction).

Tools: scripting languages

- Benefits of a scripting language (Perl, Python, Tcl, sh):
  - Interpreted: you don't have to recompile.
  - High level data types (extensible arrays, hash tables).
  - High level system functions (file I/O, string manipulation, networking).
  - Regular expressions for parsing/scanning strings and files.
- Tk is a windowing library that may be used with any of the above to quickly "script" a GUI.
- Disadvantages:
  - Interpreted code is generally slower than compiled code.
  - Missing or flaky OO features (except Python).
  - Less support for proprietary libraries and existing code.

Tools: Visual programming environments

- Visual Basic (and similar products such as Symantec Café) let you:
  - Drag and drop to create an interface.
  - Define attributes and methods from menus.
  - Access lots of existing, reusable code.
- VB is probably the very fastest way to put together a functional program with a sophisticated graphical user interface.
- Disadvantages:
  - VB programs may be slower, larger and less robust than equivalent programs written with (say) Visual C++.
  - VB programs are in no way portable to a operation system other than windows.
  - VB programs may not be able access as many libraries and Windows internals as C++ programs can.

Tools: database development tools

- Database development tools (such as MS Access) allow:
  - Graphical design of a database and corresponding user interfaces (data entry, reports).
  - Access to different databases (you can “bring together” various existing databases).
- These tools are particularly useful to try out the features of a complex database schema, particularly if you’re not very familiar with SQL.
- Disadvantages:
  - MS Access isn’t portable off of Windows (and Mac?) platforms, though you may be able to use it to develop portable SQL statements.
  - Performance and external interfaces may be lacking (though not if you’re using, for example, SQL Server and IIS on Windows NT).

Tools: “real” languages

- You may find it convenient to code your prototype in a real language, like Java. Reasons include:
  - Your final product will be in Java.
  - You’re more familiar with Java (you can start using it now, while training on the implementation language).
  - AWT and Swing are flexible, powerful windowing libraries.
  - Java provides easier, safer networking and threads than C.
  - Java is type-safe and object-oriented.
- Disadvantages:
  - Programming in Java is usually slower than in, for example, Perl; there’s nothing “rapid” about prototyping in Java.
  - It takes more work to get something going in Java (particularly user interfaces); likewise it takes longer to change it, and thus it’s harder to try ideas.

How do I choose a prototyping tool?

- Some considerations in choosing a prototyping too:
  - Do you want to reuse the code?
  - Are you focusing on the user interface? The behavior? Internal implementations?
  - How many prototypes are you doing? Will you want to extend this one?
  - What tools do you know already?
  - What tools might be useful later (and are thus worth learning/practicing now)?

Scenarios

- The next few slides present three imaginary example project scenarios. Each describes the project, then describes a series of prototypes, their focus, and the tools they'll use.

Scenario: A web application, 1

- Project: amazon.com, or a subset thereof. Ie, an e-commerce web site for selling books, with a shopping cart and credit card payment. The final system will be database-backed dynamic web pages via CGIs coded in Perl.
- Prototype 1, technical feasibility: a Perl program that makes credit card transactions work (probably by working with a library provided by an e-commerce service or bank. If this can't be made to work, the implementation language will have to be changed. If it still doesn't work, the project is doomed.

Scenario: A web application, 2

- Prototype 2, basic UI: a set of static web pages demonstrating the product search, product display, shopping cart contents, checkout and billing form screens look like. The page layouts will be there, but the team won't spend too much time on making them "pretty". The prototype will be modified iteratively in conjunction with the customer, until s/he is happy.
- Prototype 3, full demo: the pages from 2 are backed by functional scripts; a user may access the site, search for a product, add it to his/her cart, and then buy it. Credit transactions and inventory management may not be integrated yet. Again, the customer is consulted to make sure s/he approves of the interface and features.

Scenario: GUI application

- Project: A “slideshow” editor. The user can have a series of “slides” and switch back and forth between them. The user can add more or less arbitrary text to a slide. The system should be able to save slideshows to the disk and then open them again. The system should be in Java (for platform independence).
- Prototype 1, UI: A mock-up of the main application window in Visual Basic. It has all the buttons, tool bars, menus and main slide editing window, but they don’t do anything. The prototype is shown to the customer and a few of the future users, and refined according to their comments.
- Prototype 2, editing a slide: An rough start at the main slide-editing functionality, in Java. This prototype is for the use of the developers, to insure that they know how to do it, and to get an idea of the time required to finish the full project. Some code may be reuseable, but it will probably need to be redone.

Scenario: Application with no UI

- Project: Implement a simple, fast web server in C. The server should support the full HTTP protocol, including support for CGI and cookies.
- Prototype 1, making sure we can code C: The first prototype implements a very basic server which takes client requests and answers 'OK'. The server has to do networking with sockets, has to be able to handle multiple requests simultaneously (threads or multi-process?) and has to be in C. This exercise proves the skills of the development team. The code may be reused if it is good; otherwise it will be redone in the construction phase.
- Prototype 2, getting the behavior right: The second prototype helps the team understand the the HTTP, CGI and Cookie protocols, so to implement them correctly. This prototype need not be fast, robust or handle multiple connections. The prototype will be in Perl or Python, for their easy, safe data structures and string processing and easy networking libraries. The final prototype should correctly implement the protocols, so to serve as an example to the real implementation in C.

Exercise: design your own prototypes

- Project: A web-based email client. Columbia wants a full-featured email client on the web, so that students can check their cunix email from anywhere. The system has to be extremely intuitive and easy-to-use.
- Step 1: Identify a set of requirements for the systems function and interface. Of these, which are most important (which have the highest priority)?
- Step 2: Suggest one or more prototypes to help in the following:
  - The customer negotiations (figuring out what CU wants, what they mean by “full-featured”).
  - The design (how should the development team decide on an implementation? What are the hard parts of the implementation?).
  - The users perspective (how does the team develop a good, intuitive, easy-to-use interface?).