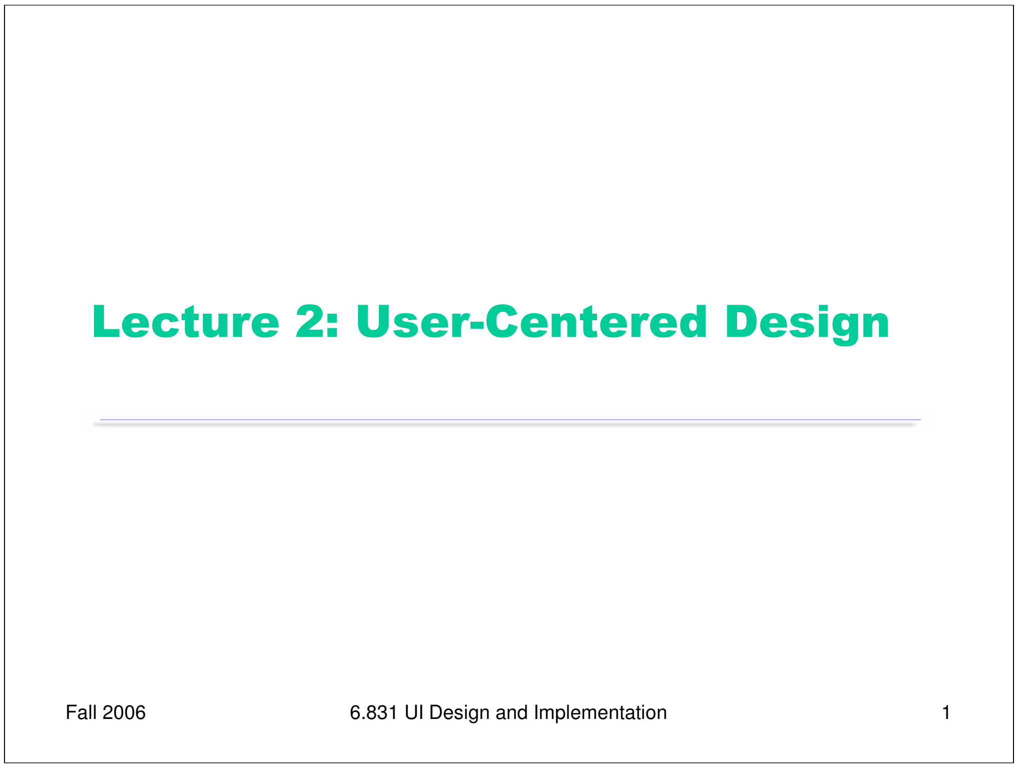
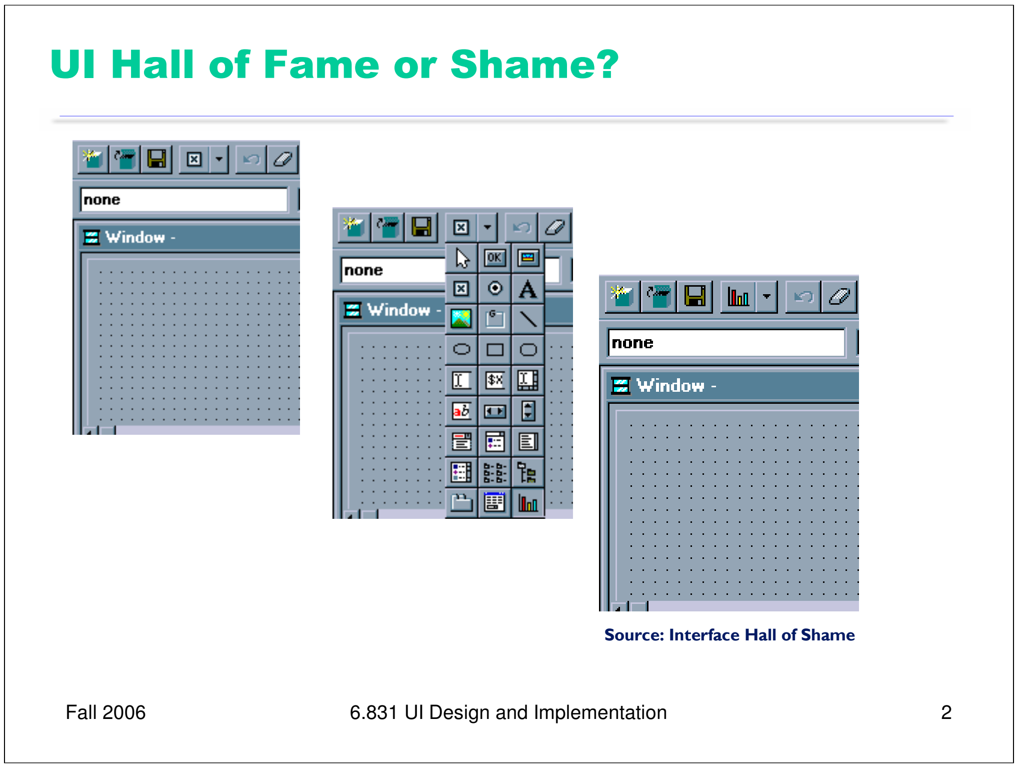
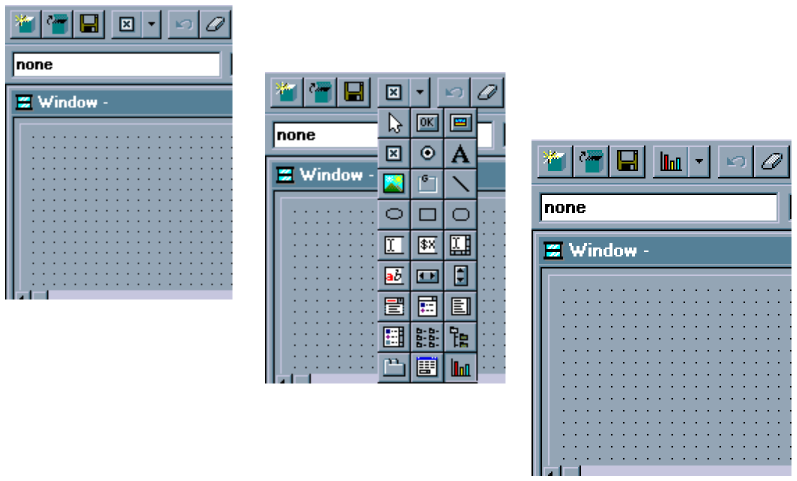


Lecture 2: User-Centered Design



UI Hall of Fame or Shame?



Source: Interface Hall of Shame

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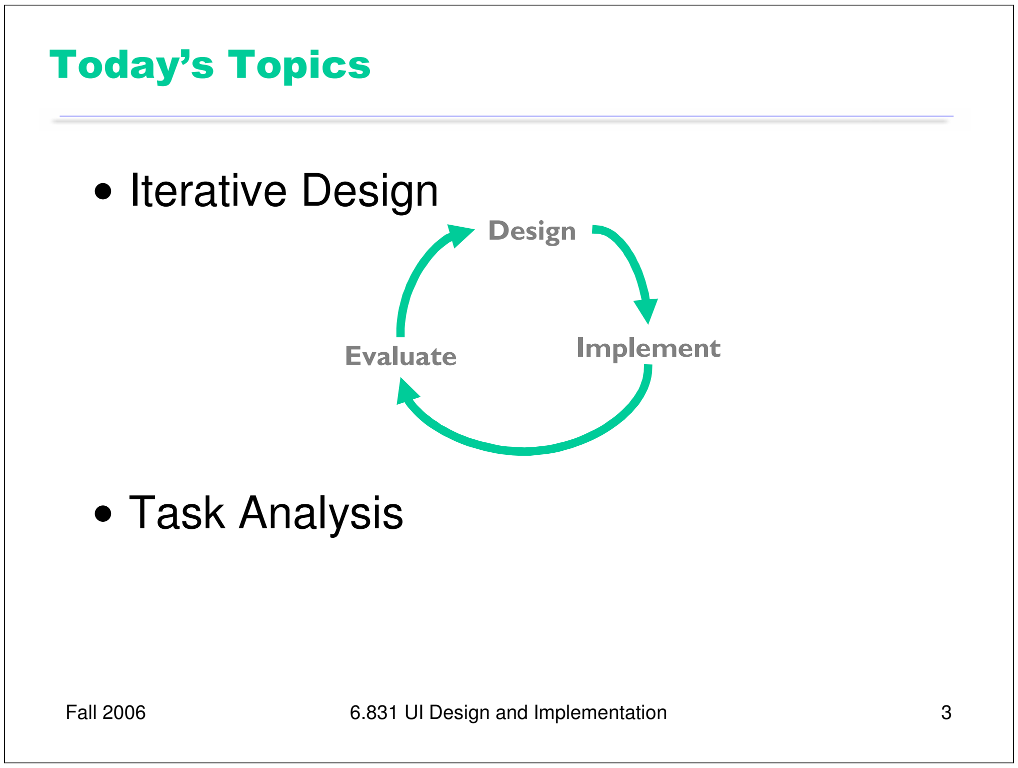
Sybase PowerBuilder is an application development environment, not unlike Microsoft Visual Basic. Users of PowerBuilder construct forms by drawing controls (buttons, listboxes, graphical objects) on the form.

Controls are selected by pulling down a menu from a toolbar icon. The menu actually looks like a palette, but it behaves like a pulldown menu in that once you make a selection, it disappears. After a control is selected, its icon is shown in the toolbar, and clicking on the form drops the control where you clicked.

This design solves some interesting problems. Most of the time, the palette is hidden, saving screen real estate that the user might prefer to use to view the form being created. It makes it easy to drop multiple instances of the same kind of control on the form – an array of textboxes, for example, or several command buttons. The current palette mode is displayed even when the palette isn't visible.

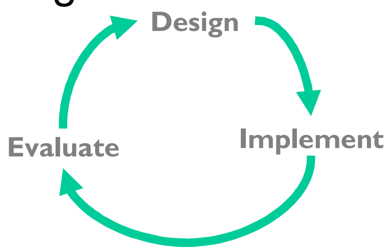
But that last feature leads to the unfortunate problem with this design: the toolbar icon is different every time the user tries to find it! Even frequent PowerBuilder users report the disconcerting feeling of hunting around for this button. The button is always in the same place, but that doesn't make it easy to find, since it's located in the midst of other toolbar buttons. Shape is the best discriminator here, but the icon keeps changing shape.

A task that probably seemed trivial to PowerBuilder's developers – the user *must* know where that button was, since they've already used it! – turns out not to be trivial at all.



Today's Topics

- Iterative Design



- Task Analysis

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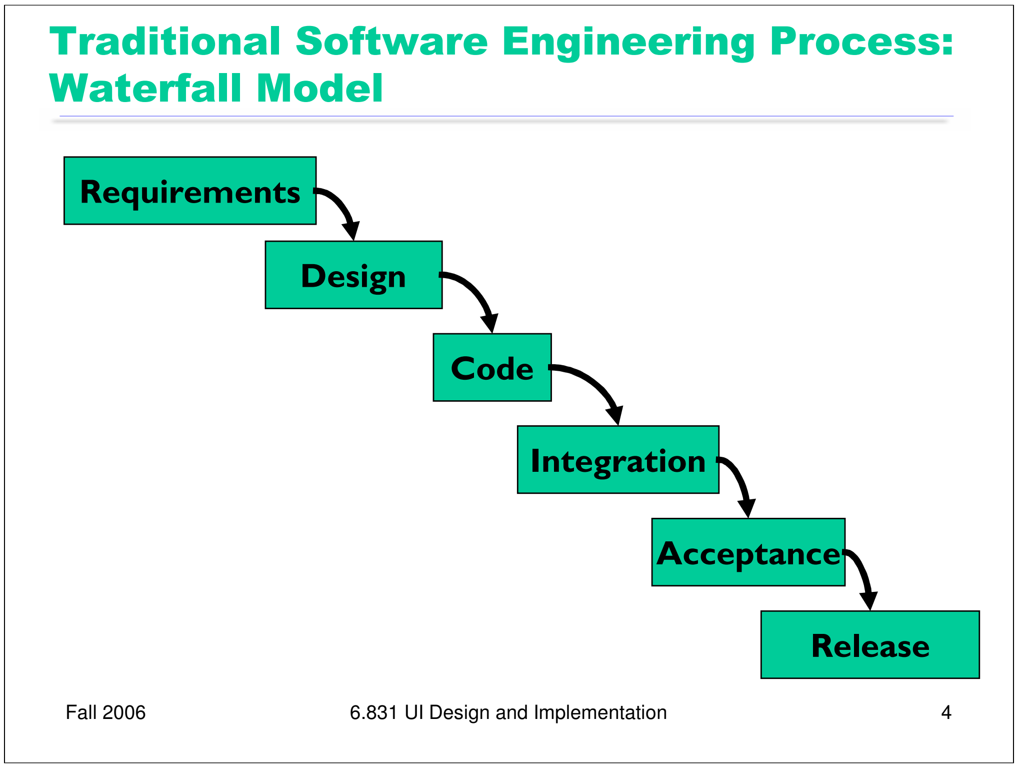
Today's lecture concerns two topics.

First, we'll look at UI design from a very high-level, considering the shape of the process that we should use to build user interfaces. **Iterative design** is the current best-practice process for developing user interfaces. It's a specialization of the spiral model described by Boehm for general software engineering. Your term project is structured as an iterative design.

Second, we'll look at how to get started with UI design – how to start the crank and get the UI design cycle going. **Task analysis** is the process by which you discover the characteristics of your target users and the tasks that they need to solve.



Traditional Software Engineering Process: Waterfall Model

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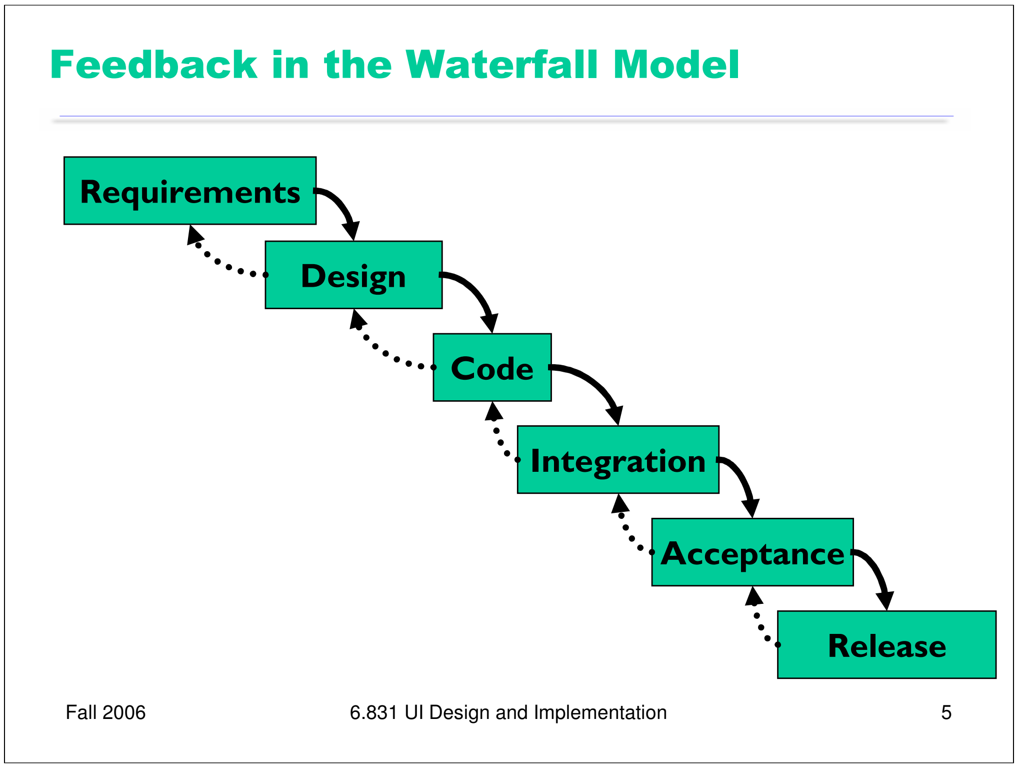
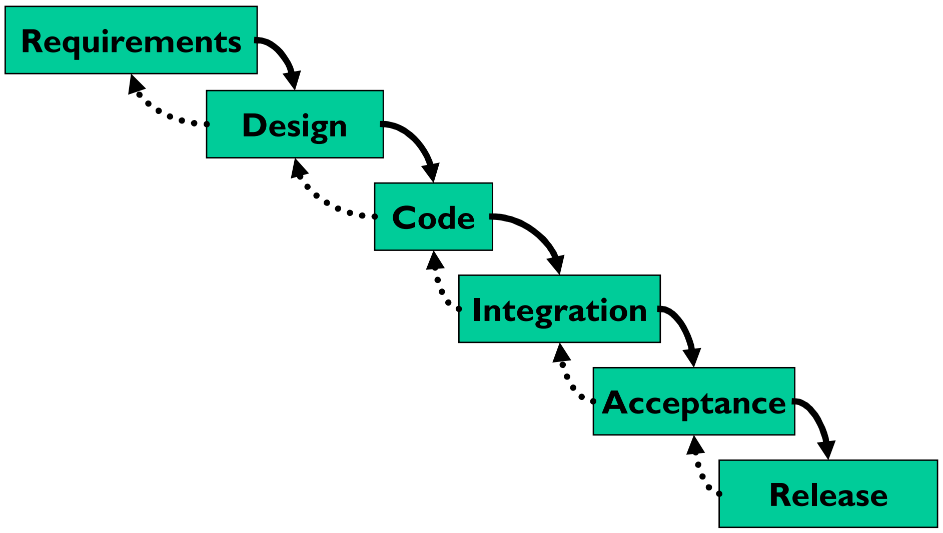
The **waterfall model** was one of the earliest carefully-articulated design processes for software development. It models the design process as a sequence of stages. Each stage results in a concrete product – a requirements document, a design, a set of coded modules – that feeds into the next stage. Each stage also includes its own **validation:** the design is validated against the requirements, the code is validated (unit-tested) against the design, etc.

The biggest improvement of the waterfall model over previous (chaotic) approaches to software development is the discipline it puts on developers to **think first, and code second**. Requirements and designs generally precede the first line of code.

If you've taken 6.170 (or a similar software engineering course), you've experienced this process yourself. The lecturers handed you a set of requirements for the software you had to build --- e.g. the specification of GizmoBall or Antichess. (In the real world, identifying these requirements would be part of your job as software developers.) You were then expected to meet certain milestones for each stage of your project, and each milestone had a concrete product: (1) a design document; (2) code modules that implemented certain functionality; (3) an integrated system.

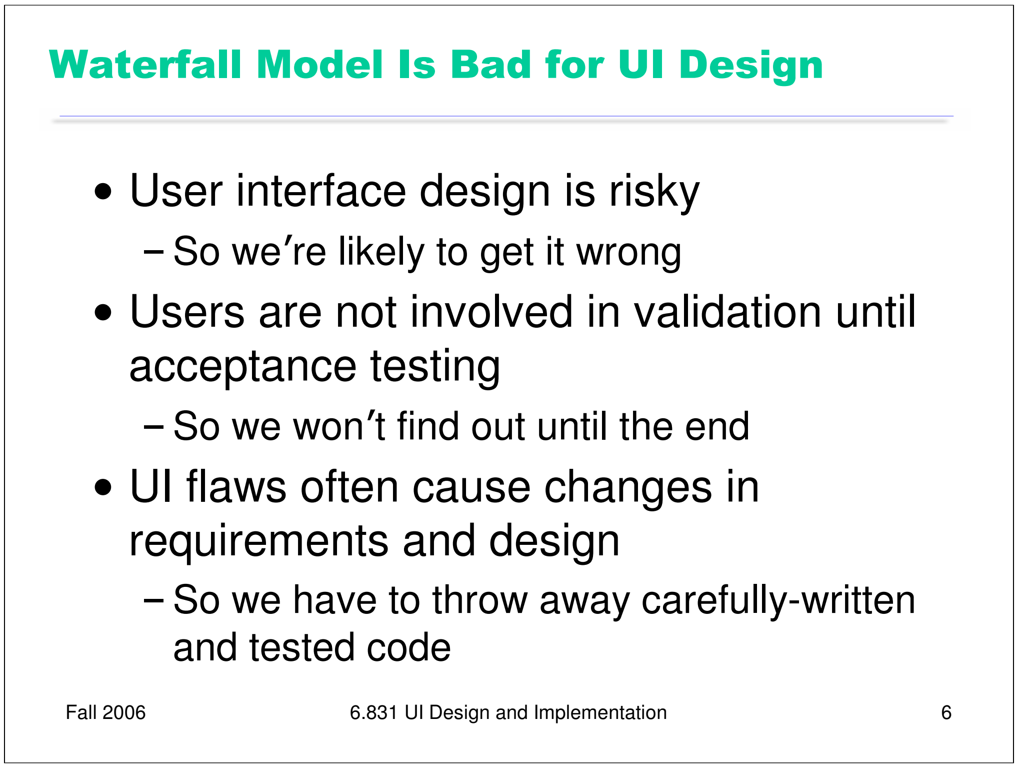


Feedback in the Waterfall Model



Validation is not always sufficient; sometimes problems are missed until the next stage. Trying to code the design may reveal flaws in the design – e.g., that it can't be implemented in a way that meets the performance requirements. Trying to integrate may reveal bugs in the code that weren't exposed by unit tests. So the waterfall model implicitly needs **feedback between stages**.

The danger arises when a mistake in an early stage – such as a missing requirement – isn't discovered until a very late stage – like acceptance testing. Mistakes like this can force costly rework of the intervening stages. (That box labeled "Code" may look small, but you know from experience that it isn't!)



Waterfall Model Is Bad for UI Design

- User interface design is risky
  - So we're likely to get it wrong
- Users are not involved in validation until acceptance testing
  - So we won't find out until the end
- UI flaws often cause changes in requirements and design
  - So we have to throw away carefully-written and tested code

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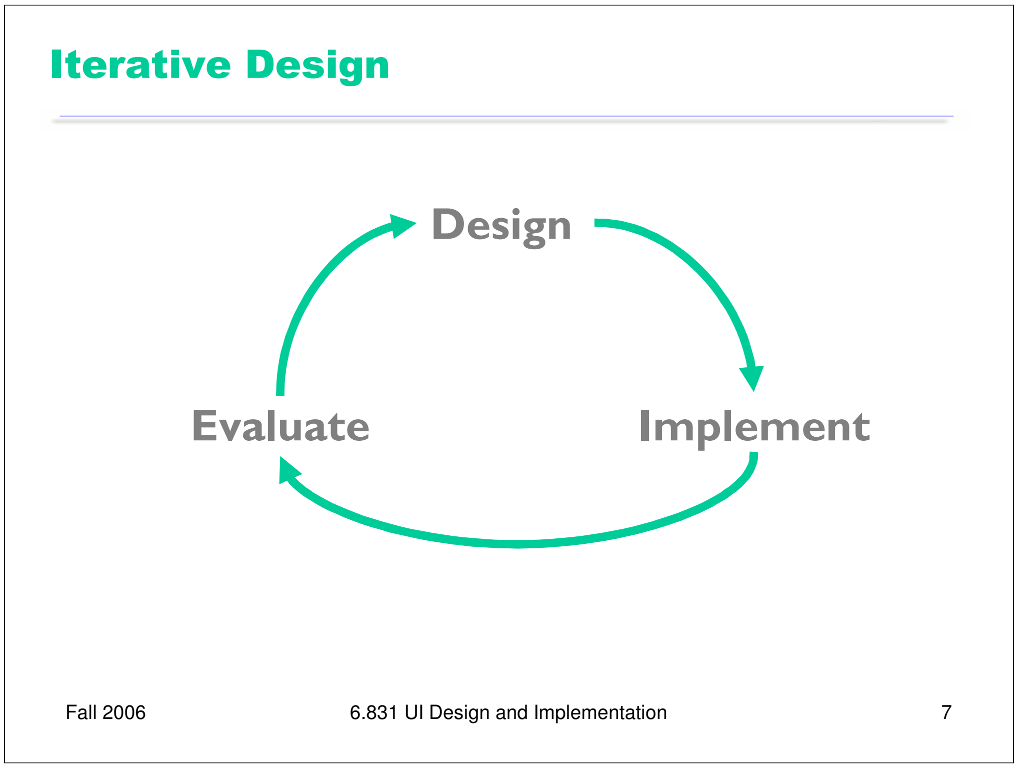
Although the waterfall model is useful for some kinds of software development, it's very poorly suited to user interface development.

First, UI development is inherently **risky**. UI design is hard for all the reasons we discussed in the previous lecture. (You are not the user; the user is always right, except when the user isn't; users aren't designers either.) We don't (yet) have an easy way to predict how whether a UI design will succeed.

Second, in the usual way that the waterfall model is applied, **users appear in the process in only two places**: requirements analysis and acceptance testing. Hopefully we asked the users what they needed at the beginning (requirements analysis), but then we code happily away and don't check back with the users until we're ready to present them with a finished system. So if we screwed up the design, the waterfall process won't tell us until the end.

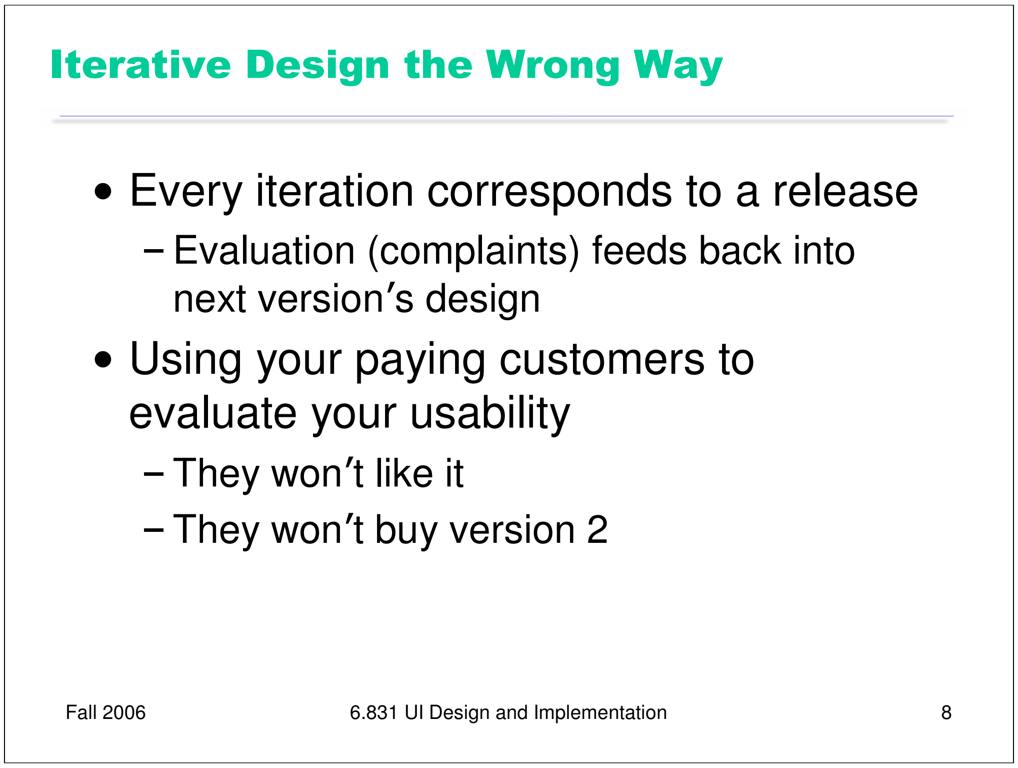
Third, when UI problems arise, they often **require dramatic fixes**: new requirements or new design. We saw last lecture that slapping on patches doesn't fix serious usability problems.



Iterative Design

Iterative design offers a way to manage the inherent risk in user interface design. In iterative design, the software is refined by repeated trips around a design cycle: first imagining it (design), then realizing it physically (implementation), then testing it (evaluation).

OK – but this just looks like the worst-case waterfall model, where we made it all the way from design to acceptance testing before discovering a design flaw that forced us to repeat the process! What's the trick here?



Iterative Design the Wrong Way

- Every iteration corresponds to a release
  - Evaluation (complaints) feeds back into next version's design
- Using your paying customers to evaluate your usability
  - They won't like it
  - They won't buy version 2

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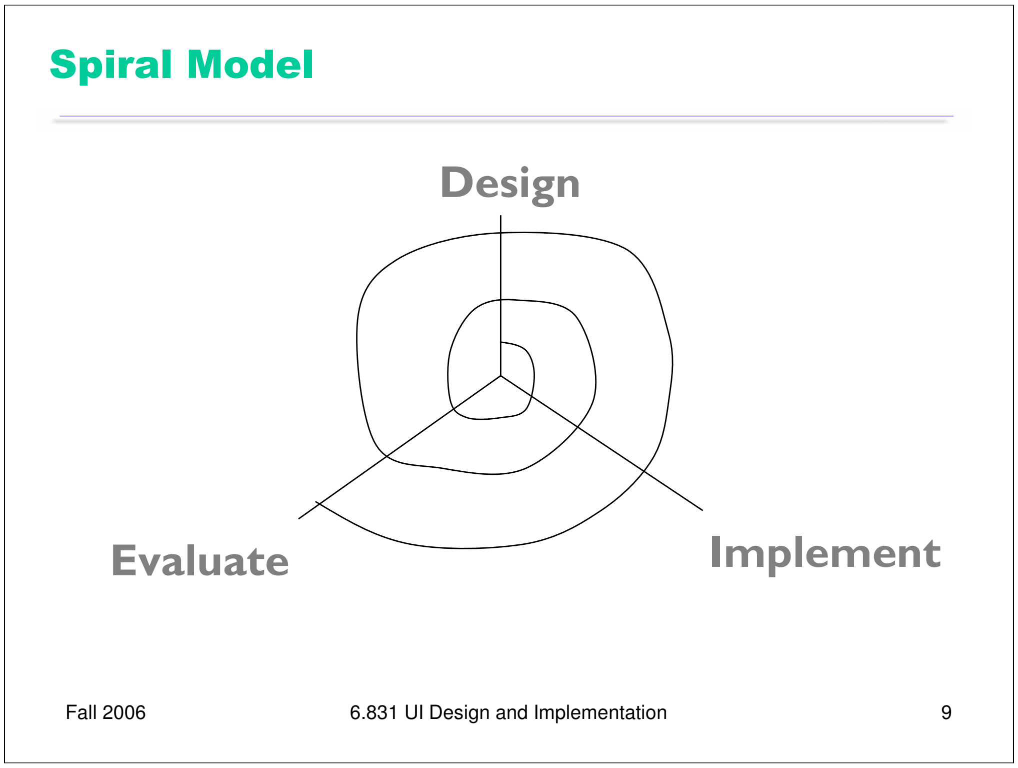
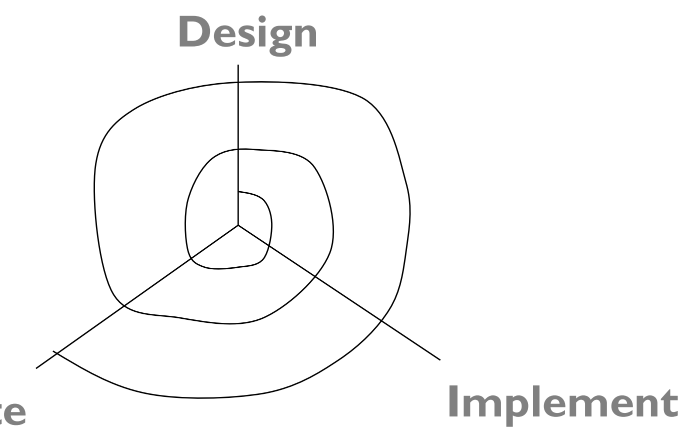
Unfortunately, many commercial UI projects have followed this model. They do a standard waterfall design, produce a bad UI, and release it. Evaluation then takes place in the marketplace, as hapless customers buy their product and complain about it. Then they iterate the design process on version 2.



Spiral Model



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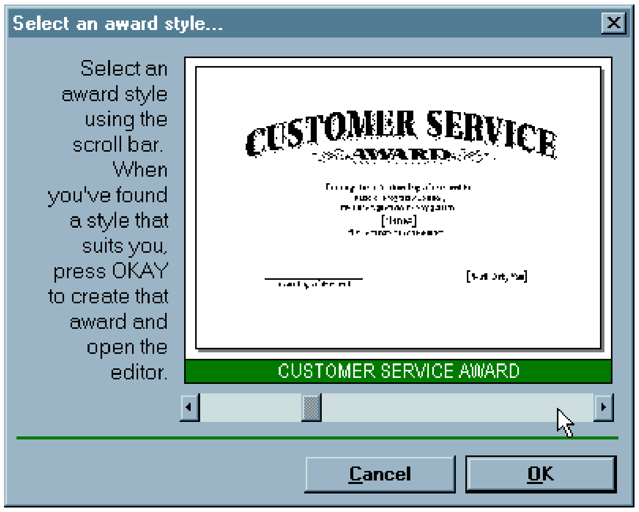
The **spiral model** offers a way out of the dilemma. We build room for several iterations into our design process, and we do it by making the early iterations as cheap as possible.

The radial dimension of the spiral model corresponds to the **cost** of the iteration step – or, equivalently, its **fidelity** or **accuracy**. For example, an early implementation might be a paper sketch or mockup. It's low-fidelity, only a pale shadow of what it would look and behave like as interactive software. But it's incredibly cheap to make, and we can evaluate it by showing it to users and asking them questions about it.

Early Prototypes Can Detect Usability Problems

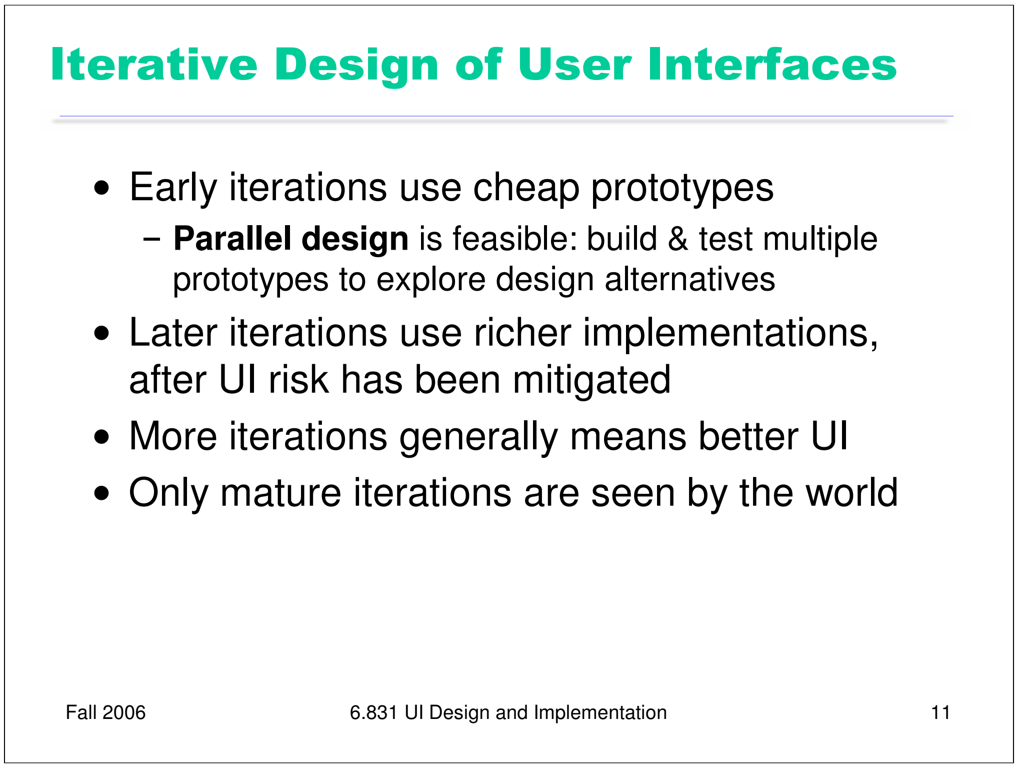


Select an award style...

Select an award style using the scroll bar. When you've found a style that suits you, press OKAY to create that award and open the editor.

CUSTOMER SERVICE AWARD

Remember this Hall of Shame candidate from last lecture? This dialog's design problems would have been easy to catch if it were only tested as a simple paper sketch, in an early iteration of a spiral design. At that point, changing the design would have cost only another sketch, instead of a day's code.


Iterative Design of User Interfaces

- Early iterations use cheap prototypes
  - **Parallel design** is feasible: build & test multiple prototypes to explore design alternatives
- Later iterations use richer implementations, after UI risk has been mitigated
- More iterations generally means better UI
- Only mature iterations are seen by the world

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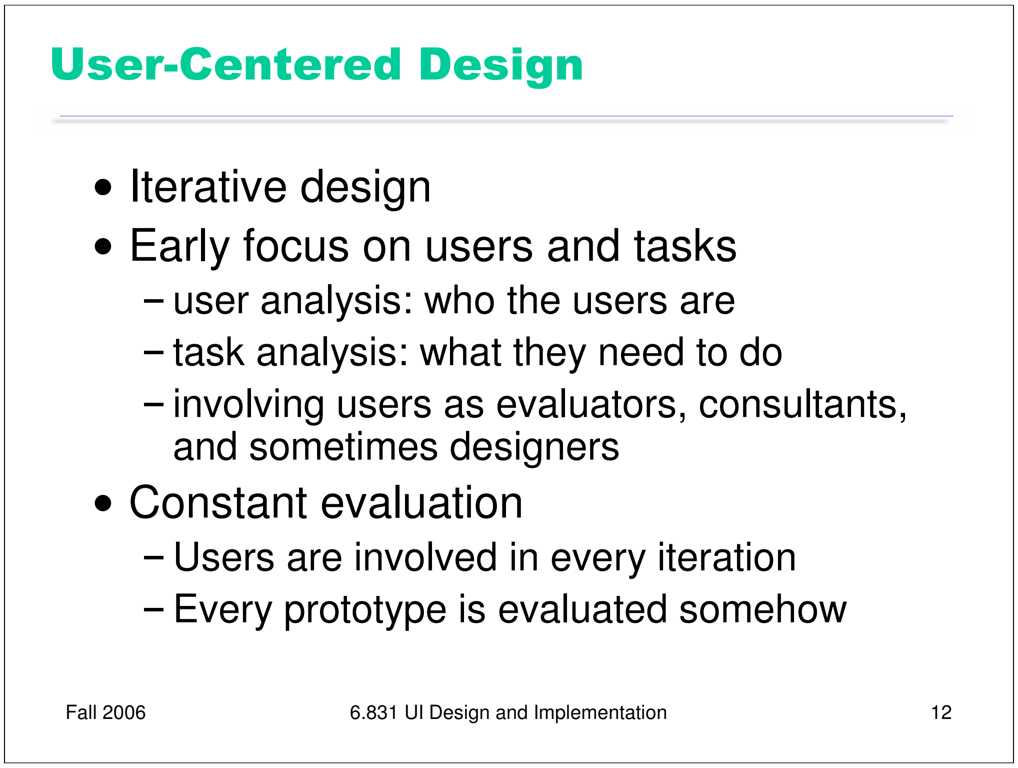
Why is the spiral model a good idea? Risk is greatest in the early iterations, when we know the least. So we put our least commitment into the early implementations. Early prototypes are made to be thrown away. If we find ourselves with several design alternatives, we can build multiple prototypes (**parallel design**) and evaluate them, without much expense.

After we have evaluated and redesigned several times, we have (hopefully) learned enough to avoid making a major UI design error. Then we actually implement the UI – which is to say, we build a prototype that we intend to keep. Then we evaluate it again, and refine it further.

The more iterations we can make, the more refinements in the design are possible. We're hill-climbing here, not exploring the design space randomly. We keep the parts of the design that work, and redesign the parts that don't. So we should get a better design if we can do more iterations.



User-Centered Design

- Iterative design
- Early focus on users and tasks
  - user analysis: who the users are
  - task analysis: what they need to do
  - involving users as evaluators, consultants, and sometimes designers
- Constant evaluation
  - Users are involved in every iteration
  - Every prototype is evaluated somehow

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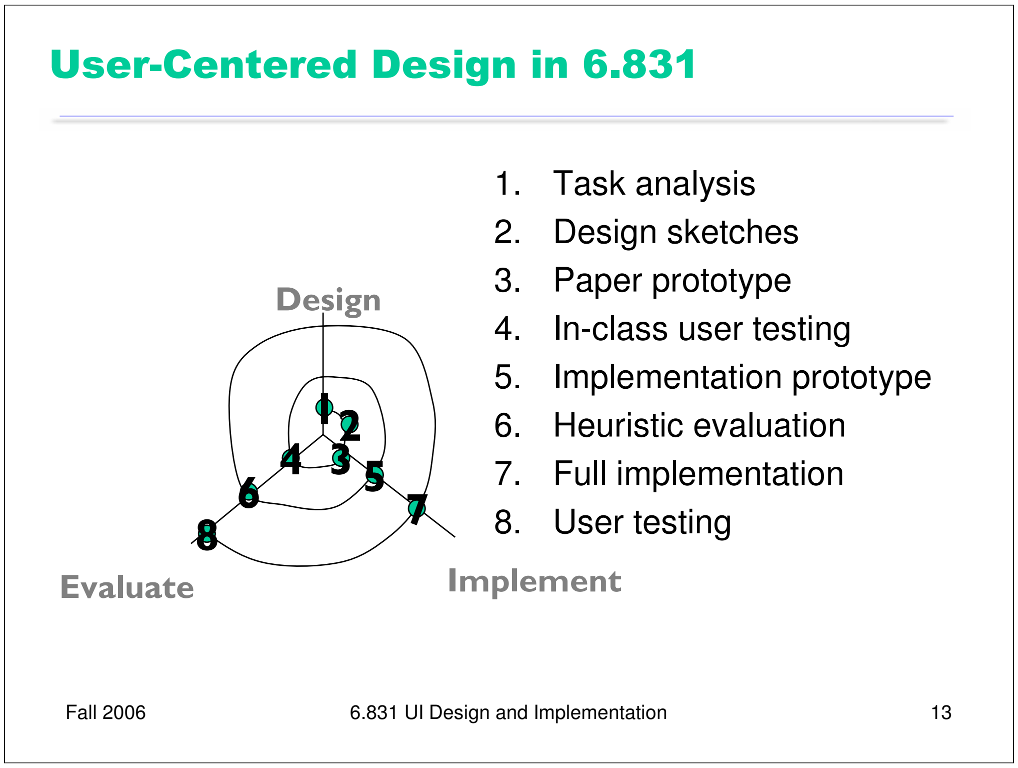
Iterative design is a crucial part of **user-centered design**, the design process for user interfaces that is widely accepted among UI practicioners. A variety of brand-name user-centered design techniques exist (e.g., GUIDE, STUDIO, OVID, LUCID). But most have three features in common:

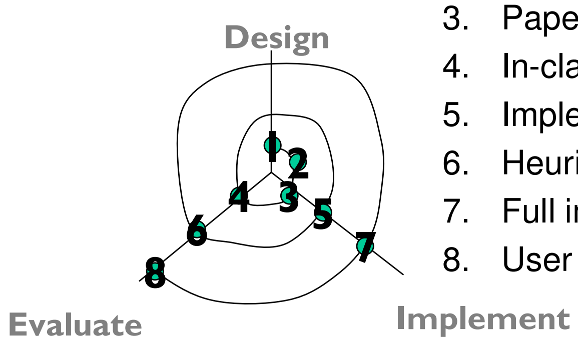
- iterative design using rapid prototyping

- early focus on users and tasks

- evaluation throughout the iterative design process.



User-Centered Design in 6.831



1. Task analysis
2. Design sketches
3. Paper prototype
4. In-class user testing
5. Implementation prototype
6. Heuristic evaluation
7. Full implementation
8. User testing

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The term project's milestones are designed to follow a spiral model:

1. task analysis (1 week): collecting the requirements for the UI, which we'll discuss in the second half of this lecture.

2. design sketches (1 week): paper sketches of your UI design

3. paper prototype (2 weeks): an interactive prototype made of paper and other cheap physical materials

4. in-class user testing (1 day): one day during the paper prototype assignment, we'll spend the lecture using each others' prototypes

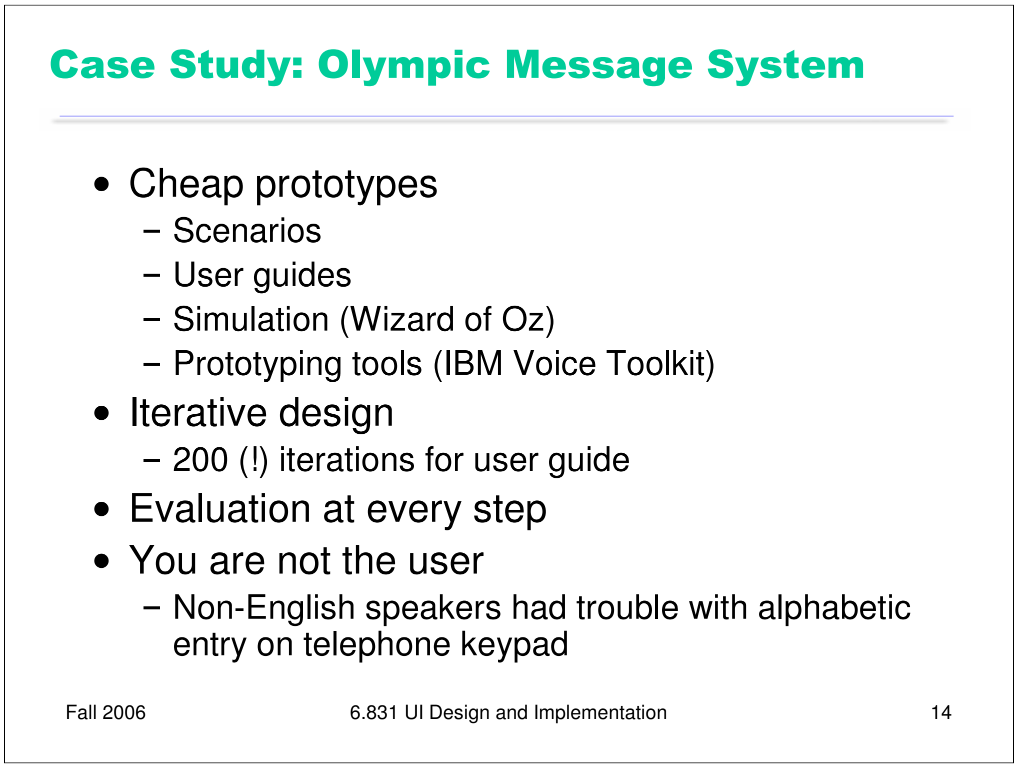
5. implementation prototype (2 weeks): an incomplete but interactive software prototype

6. heuristic evaluation (1 week): we'll exchange implementation prototypes and evaluate them as usability experts would

7. full implementation (3 weeks): you'll build a real implementation that you plan to keep

8. user testing (2 weeks): you'll test your implementation against users and refine it

Notice that the part you did in 6.170 – step 7 – is only one milestone in this class!



Case Study: Olympic Message System

- Cheap prototypes
  - Scenarios
  - User guides
  - Simulation (Wizard of Oz)
  - Prototyping tools (IBM Voice Toolkit)
- Iterative design
  - 200 (!) iterations for user guide
- Evaluation at every step
- You are not the user
  - Non-English speakers had trouble with alphabetic entry on telephone keypad

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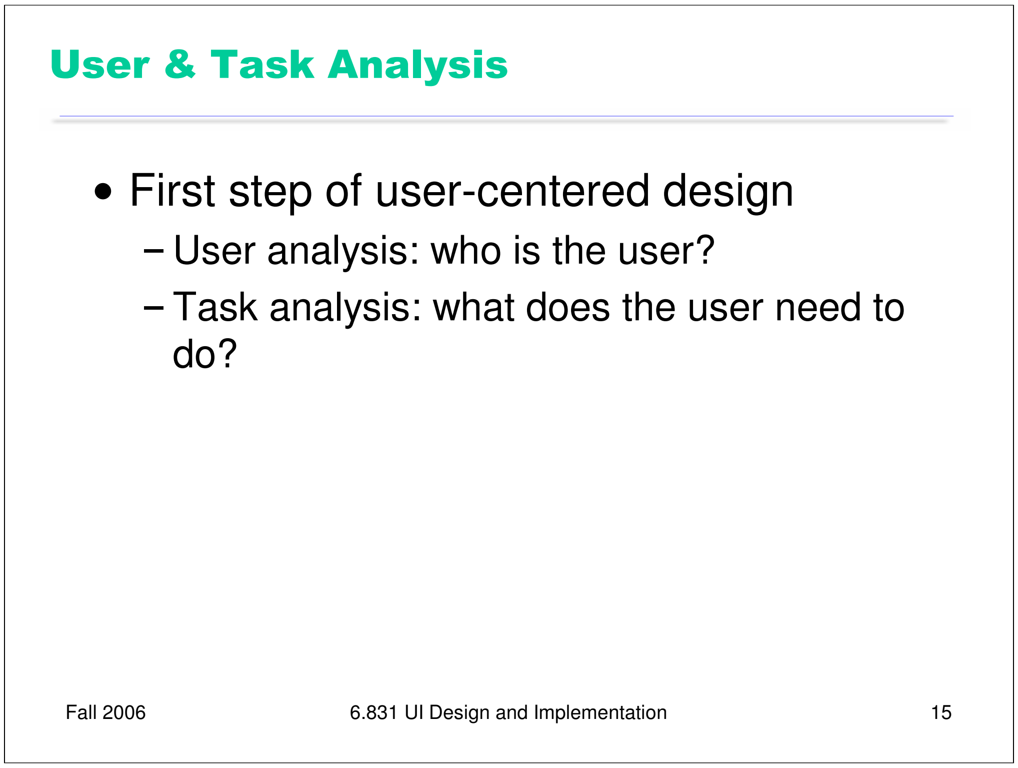
The Olympic Message System is a good demonstration of the effectiveness of user-centered design (Gould et al, "The 1984 Olympic Message System", CACM, v30 n9, Sept 1987). The OMS designers used a variety of cheap prototypes: scenarios (stories envisioning a user interacting with the system), manuals, and simulation (in which the experimenter read the system's prompts aloud, and the user typed responses into a terminal). All of these prototypes could be (and were) shown to users to solicit reactions and feedback.

Iteration was pursued aggressively. The user guide went through 200 iterations!

The OMS also has some interesting cases reinforcing the point that the designers cannot rely entirely on themselves for evaluating usability. Most prompts requested numeric input ("press 1, 2, or 3"), but some prompts needed alphabetic entry ("enter your three-letter country code"). Non-English speakers – particularly from countries with non-Latin languages – found this confusing, because, as one athlete reported in an early field test, "you have to read the keys differently." The designers didn't remove the alphabetic prompts, but they did change the user guide's examples to use only uppercase letters, just like the telephone keys.



User & Task Analysis

- First step of user-centered design
  - User analysis: who is the user?
  - Task analysis: what does the user need to do?

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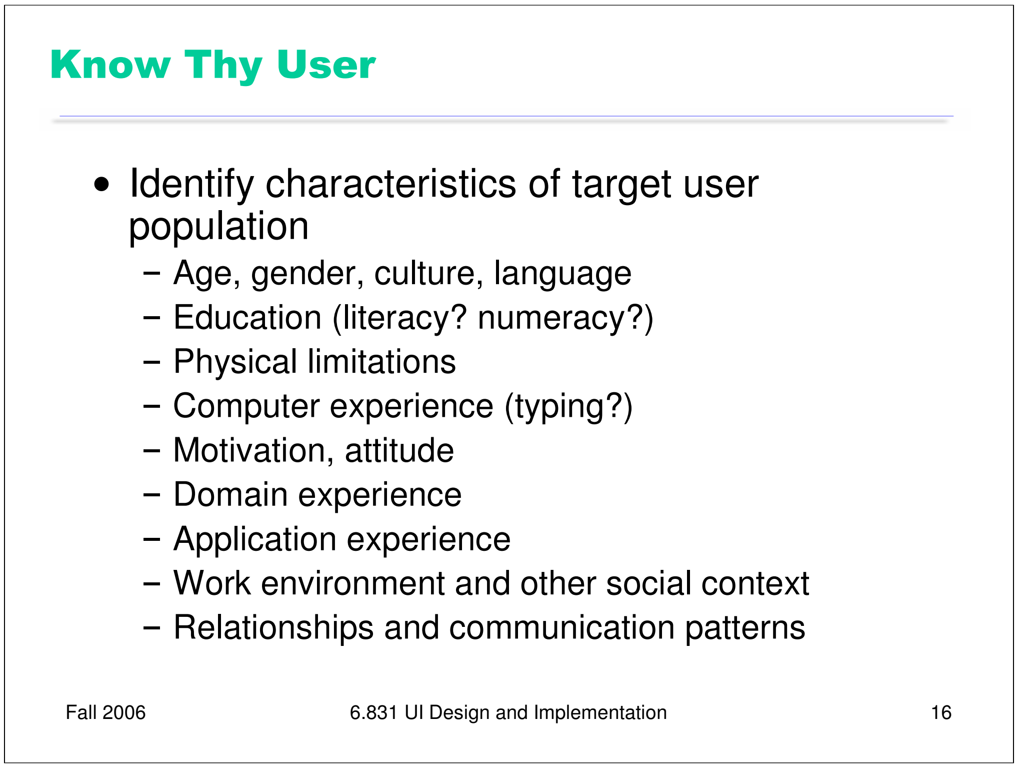
We've seen that UI design is iterative – that we have to turn the crank several times to achieve good usability. How do we get started? How do we acquire information for the initial design?

The process of collecting information for the first design is called **user and task analysis**. In these steps, we ask who the users are, and what it is that they're trying to accomplish.



Know Thy User

- Identify characteristics of target user population
  - Age, gender, culture, language
  - Education (literacy? numeracy?)
  - Physical limitations
  - Computer experience (typing?)
  - Motivation, attitude
  - Domain experience
  - Application experience
  - Work environment and other social context
  - Relationships and communication patterns

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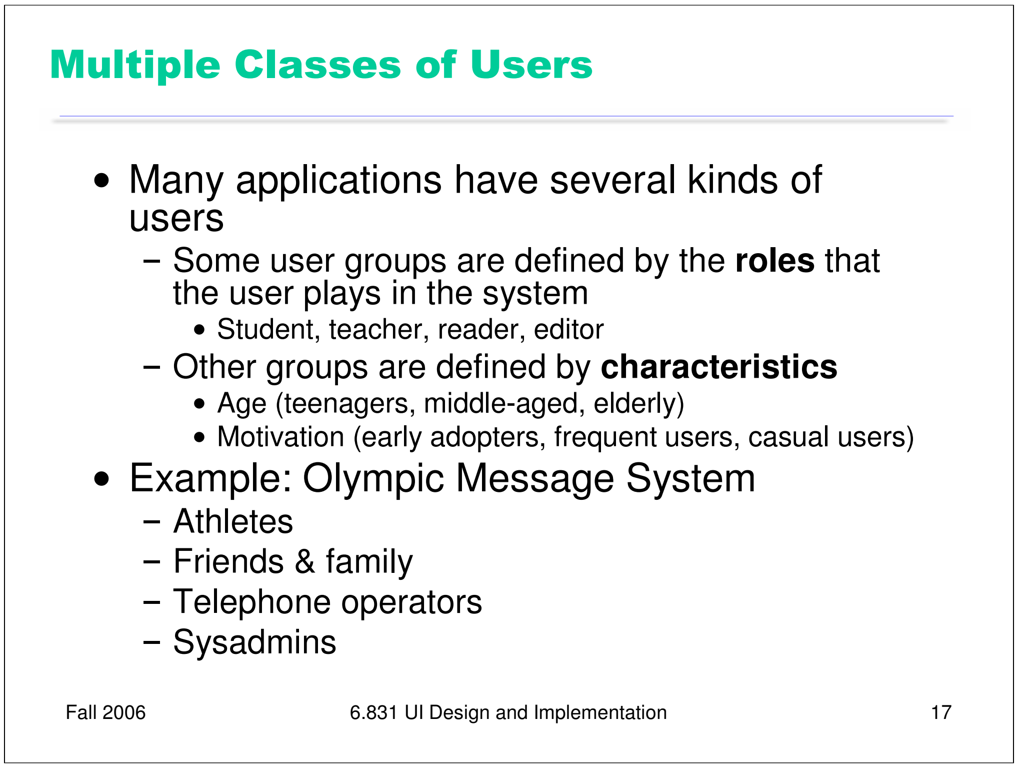
The reason for user analysis is straightforward: since you're not the user, you need to find out who the user actually is.

User analysis seems so obvious that it's often skipped. But failing to do it explicitly makes it easier to fall into the trap of assuming every user is like you. It's better to do some thinking and collect some information first.

Knowing about the user means not just their individual characteristics, but also their situation. In what environment will they use your software? What else might be distracting their attention? What is the social context? A movie theater, a quiet library, inside a car, on the deck of an aircraft carrier; environment can place widely varying constraints on your user interface.

Other aspects of the user's situation include their relationship to other users in their organization, and typical communication patterns. Can users ask each other for help, or are they isolated? How do students relate differently to lab assistants, teaching assistants, and professors?



Multiple Classes of Users

- Many applications have several kinds of users
  - Some user groups are defined by the **roles** that the user plays in the system
    - Student, teacher, reader, editor
  - Other groups are defined by **characteristics**
    - Age (teenagers, middle-aged, elderly)
    - Motivation (early adopters, frequent users, casual users)
- Example: Olympic Message System
  - Athletes
  - Friends & family
  - Telephone operators
  - Sysadmins

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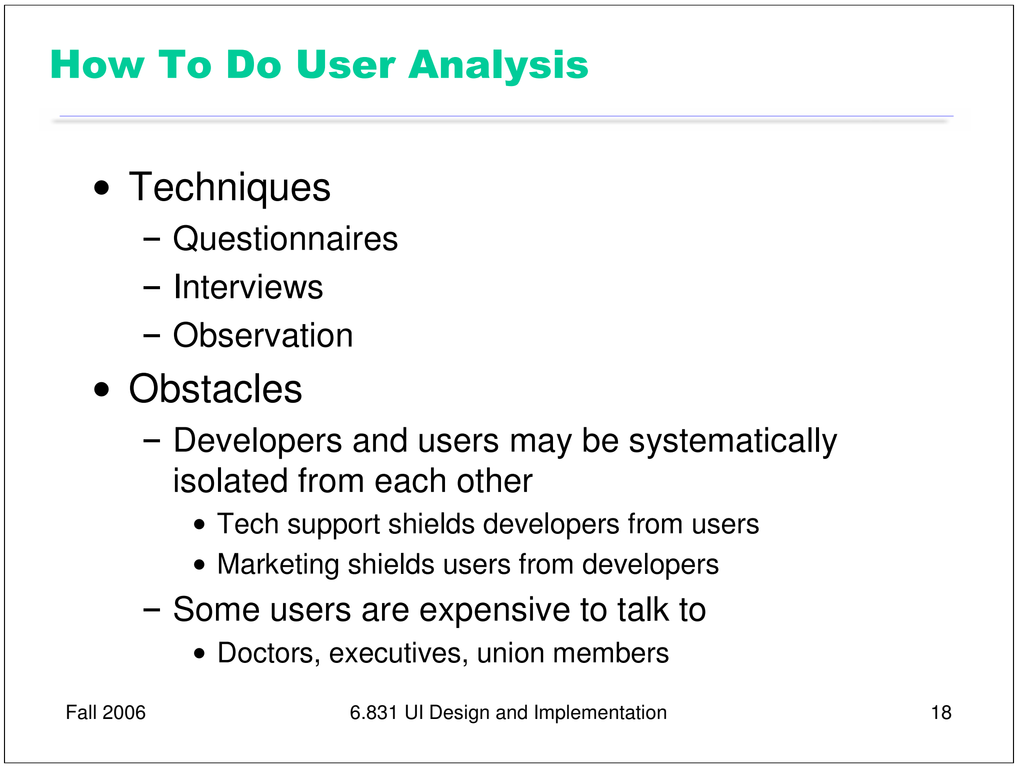
Many, if not most, applications have to worry about multiple classes of users. Do a user analysis for every class.



How To Do User Analysis

- Techniques
  - Questionnaires
  - Interviews
  - Observation
- Obstacles
  - Developers and users may be systematically isolated from each other
    - Tech support shields developers from users
    - Marketing shields users from developers
  - Some users are expensive to talk to
    - Doctors, executives, union members

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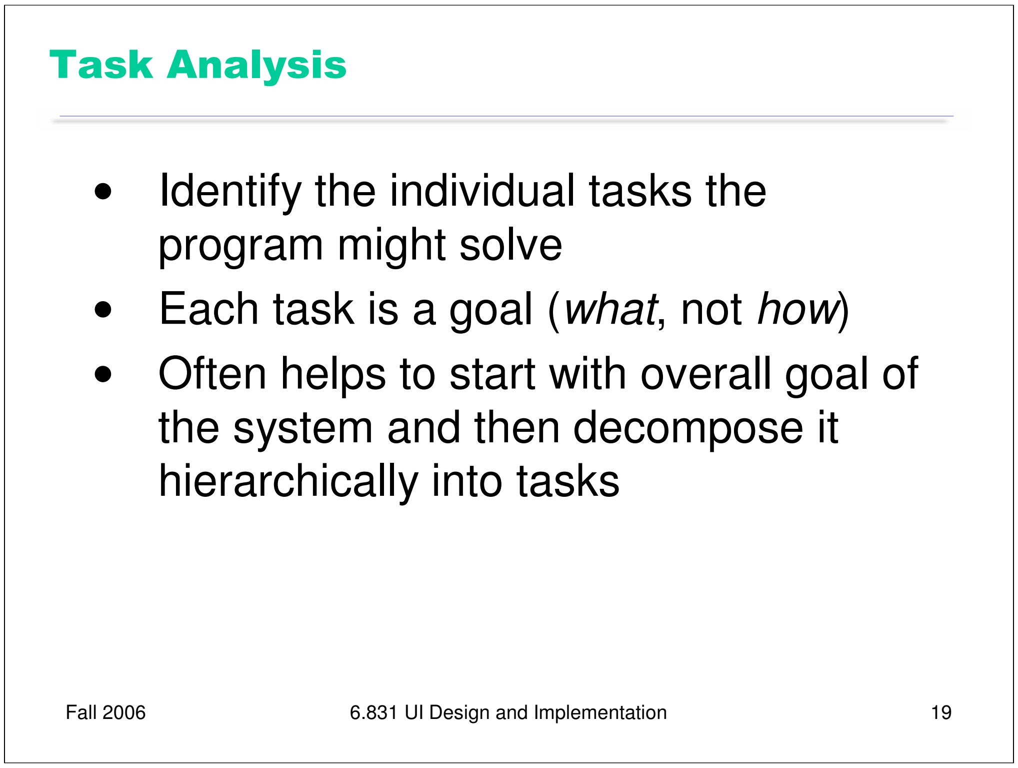
The best way to do user analysis is to find some representative users and ask them. Straightforward characteristics can be obtained by a **questionnaire**. Details about context and environment can be obtained by **interviewing** users directly, or even better, **observing** them going about their business, in their natural habitat.

Sometimes it can be hard to reach users. Software companies can erect artificial barriers between users and developers, for their mutual protection. After all, if users know who the developers are, they might pester them with bugs and questions about the software, which are better handled by tech support personnel. The marketing department may be afraid to let the developers interact with the users – not only because geeks can be scary, but also because usability discussions may make customers dissatisfied with the current product. ("I hadn't noticed it before, but that DOES suck!")

Some users are also expensive to find and talk to. Nevertheless, make every effort to collect the information you need. A little money spent collecting information initially should pay off significantly in better designs and fewer iterations.



Task Analysis

- Identify the individual tasks the program might solve
- Each task is a goal (*what*, not *how*)
- Often helps to start with overall goal of the system and then decompose it hierarchically into tasks

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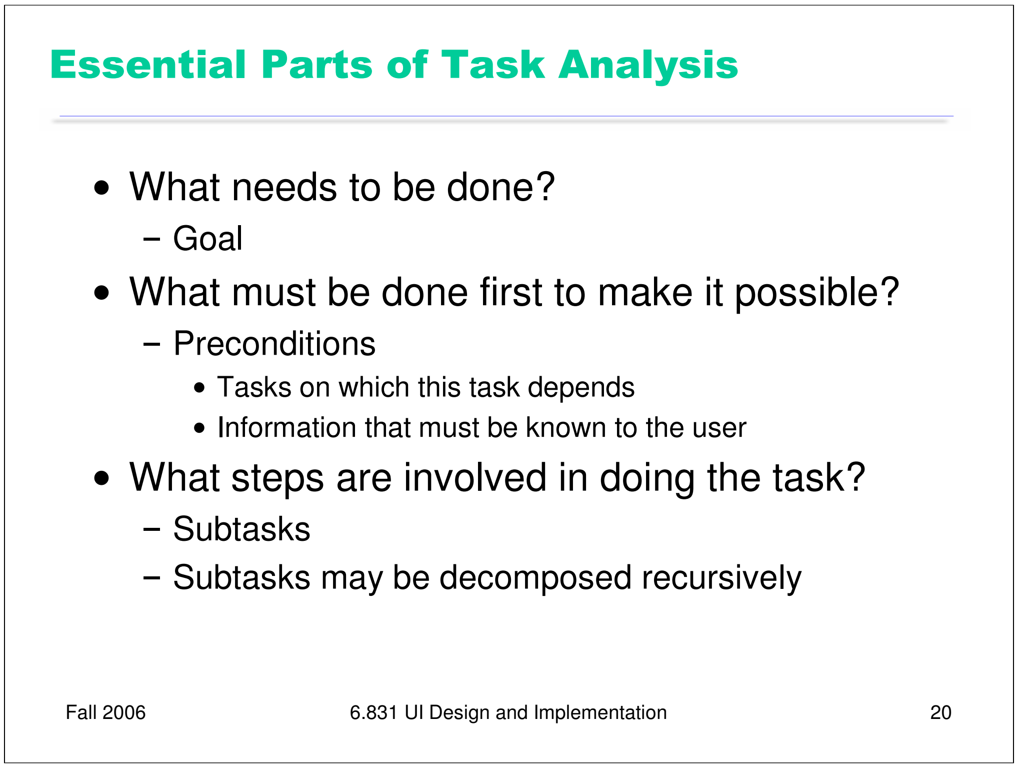
The next step is figuring out what tasks are involved in the problem. A task should be expressed as a goal: *what* needs to be done, not *how*.

One good way to get started on a task analysis is hierarchical decomposition. Think about the overall problem you're trying to solve. That's really the top-level task. Then decompose it into a set of subtasks, or subgoals, that are part of satisfying the overall goal.



Essential Parts of Task Analysis

- What needs to be done?
  - Goal
- What must be done first to make it possible?
  - Preconditions
    - Tasks on which this task depends
    - Information that must be known to the user
- What steps are involved in doing the task?
  - Subtasks
  - Subtasks may be decomposed recursively

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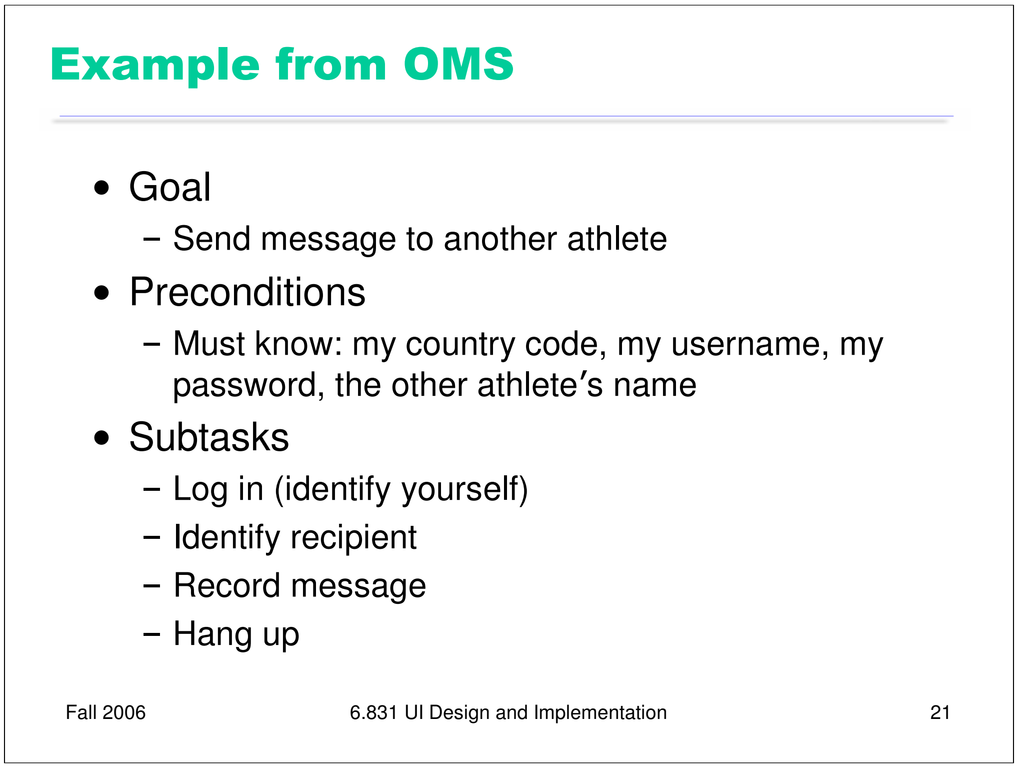
Once you've identified a list of tasks, fill in the details on each one. Every task in a task analysis should have at least these parts.

The **goal** is just the name of the task, like "send an email message."

The **preconditions** are the conditions that must be satisfied before it's reasonable or possible to attempt the task. Some preconditions are other tasks in your analysis; e.g., before you can listen to your messages in the Olympic Message System, you first have to log in. Other preconditions are **information needs**, things the user needs to know in order to do the task. For example, in order to send an email message, I need to know the email addresses of the people I want to send it to; I may also need to look at the message I'm replying to.

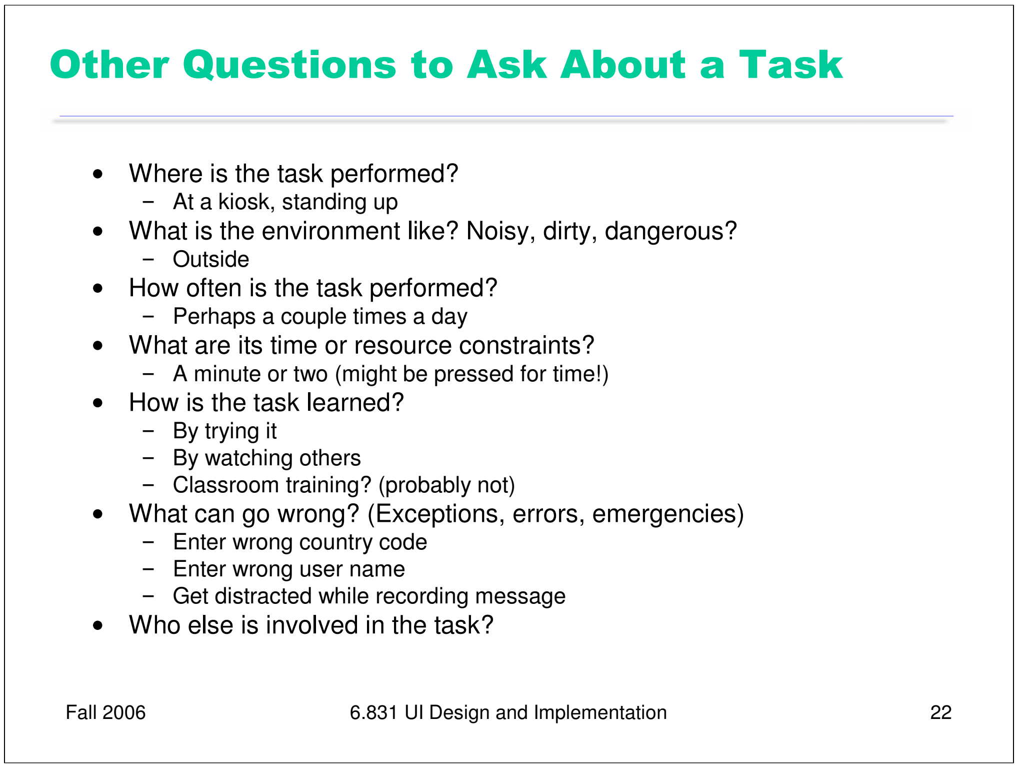
Preconditions are vitally important to good UI design, particularly because users don't always satisfy them before attempting a task, resulting in errors. Knowing what the preconditions are can help you prevent these errors, or at least render them harmless. For example, a precondition of starting a fire in a fireplace is opening the flue, so that smoke escapes up the chimney instead of filling the room. If you know this precondition as a designer, you can design the fireplace with an interlock that ensures the precondition will be met. Another design solution is to offer opportunities to complete preconditions: for example, an email composition window should give the user access to their address book to look up recipients' email addresses.

Finally, decompose the task into **subtasks**, individual steps involved in doing the task. If the subtasks are nontrivial, they can be recursively decomposed in the same manner.



Example from OMS

- Goal
  - Send message to another athlete
- Preconditions
  - Must know: my country code, my username, my password, the other athlete′s name
- Subtasks
  - Log in (identify yourself)
  - Identify recipient
  - Record message
  - Hang up



Other Questions to Ask About a Task

- Where is the task performed?
  - At a kiosk, standing up
- What is the environment like? Noisy, dirty, dangerous?
  - Outside
- How often is the task performed?
  - Perhaps a couple times a day
- What are its time or resource constraints?
  - A minute or two (might be pressed for time!)
- How is the task learned?
  - By trying it
  - By watching others
  - Classroom training? (probably not)
- What can go wrong? (Exceptions, errors, emergencies)
  - Enter wrong country code
  - Enter wrong user name
  - Get distracted while recording message
- Who else is involved in the task?

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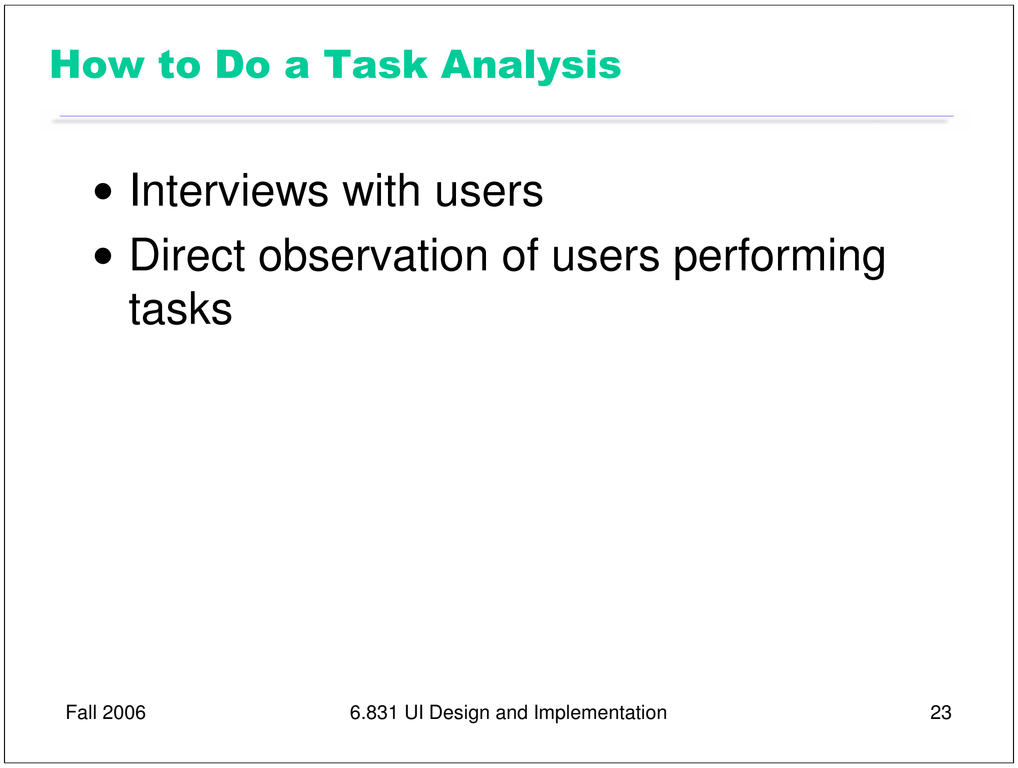
There are lots of questions you should ask about each task. Here are a few, with examples relevant to the OMS send-message task.



How to Do a Task Analysis

- Interviews with users
- Direct observation of users performing tasks

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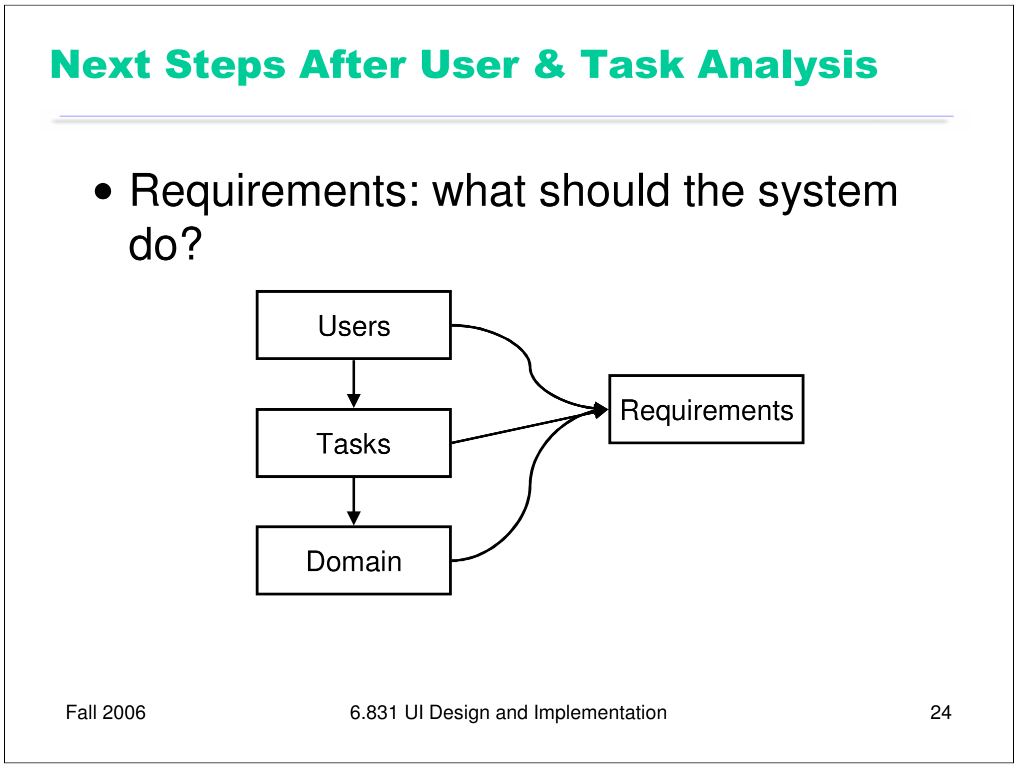
The best sources of information for task analysis are user interviews and direct observation. Usually, you'll have to observe how users *currently* perform the task. For the OMS example, we would want to observe athletes interacting with each other, and with family and friends, while they're training for or competing in events. We would also want to interview the athletes, in order to understand better their goals in the task.



Next Steps After User & Task Analysis

- Requirements: what should the system do?

$$\begin{tikzcd}
\boxed{\text{Users}} \arrow[d] \arrow[rrd, bend left] & & \\
\boxed{\text{Tasks}} \arrow[d] \arrow[rr] & & \boxed{\text{Requirements}} \\
\boxed{\text{Domain}} \arrow[rru, bend right] & &
\end{tikzcd}$$

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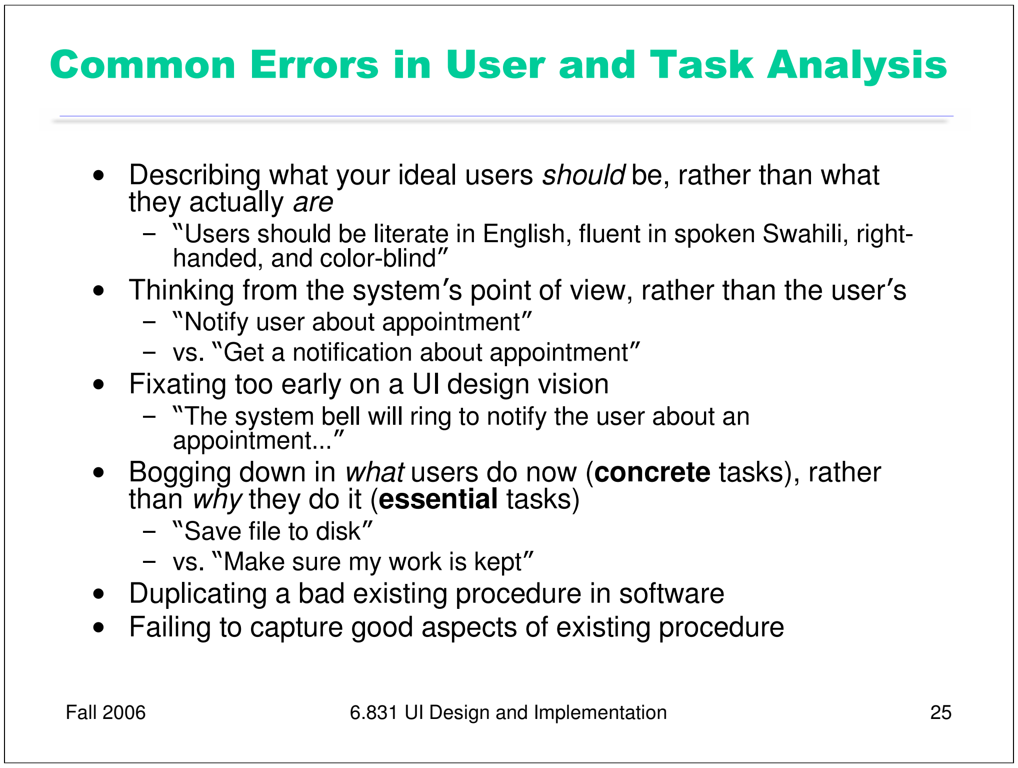
User and task analysis feed into a more general process called **requirements analysis**, which creates a description of the system's desired functionality and other nonfunctional properties (like performance, security, and capacity). Requirements analysis also generally involves a **domain analysis**, which discovers the elements of the domain and how they're related to each other. In 6.170, you probably did domain analysis by drawing object model diagrams.

Without user and task analysis, requirements are incomplete. User and task analysis contribute additional functionality (tasks that users need to do which may not be evident from the domain analysis alone) as well as nonfunctional requirements about **usability** (like how efficient certain tasks should be, or how learnable, or how memorable) and about other properties of the system as well (e.g., accommodation for users' physical limitations, like impaired vision). For example, here are some of the requirements in the OMS system that might come out of user and task analysis:

•Support twelve languages (because athletes, friends & family don't all speak the same language)

•Support non-touchtone phones (because friends & family don't all have them)

•Check Messages task should take less than 30 seconds (because athletes may be pressed for time)



Common Errors in User and Task Analysis

- Describing what your ideal users *should* be, rather than what they actually *are*
  - "Users should be literate in English, fluent in spoken Swahili, right-handed, and color-blind"
- Thinking from the system's point of view, rather than the user's
  - "Notify user about appointment"
  - vs. "Get a notification about appointment"
- Fixating too early on a UI design vision
  - "The system bell will ring to notify the user about an appointment..."
- Bogging down in *what* users do now (**concrete** tasks), rather than *why* they do it (**essential** tasks)
  - "Save file to disk"
  - vs. "Make sure my work is kept"
- Duplicating a bad existing procedure in software
- Failing to capture good aspects of existing procedure

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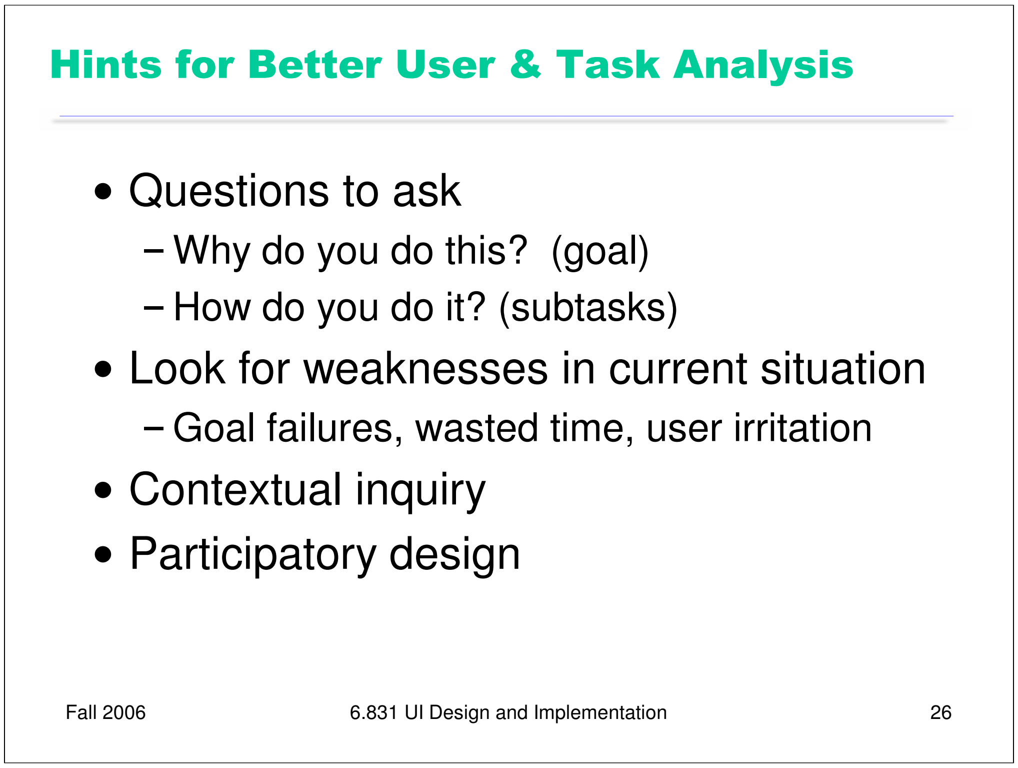
Many problems in user and task analysis are caused by jumping too quickly into a requirements mindset. In user analysis, this sometimes results in wishful thinking, rather than looking at reality. Saying "OMS users *should* all have touchtone phones" is stating a **requirement**, not a characteristic of the existing users. One reason we do user analysis is to see whether these requirements are actually satisfied, or whether we'd have to add something to the system to make sure it's satisfied. For example, maybe we'd have to offer touchtone phones to every athlete's friends and family…

The requirements mindset can also affect task analysis. If you're writing down tasks from the system's point of view, like "Notify user about appointment", then you're writing **requirements** (what the system should do), not **tasks** (what the user's goals are). Sometimes this is merely semantics, and you can just write it the other way; but it may also mean you're focusing too much on what the system *can* do, rather than what the user *wants*. Tradeoffs between user goals and implementation feasibility are inevitable, but you don't want them to dominate your thinking at this early stage of the game.

Task analysis derived from observation may give too much weight to the way things are currently done. A task analysis that breaks down the steps of a current system is **concrete**. For example, if the *Log In* task is broken down into the subtasks *Enter username* and *Enter password*, then this is a concrete task relevant only to a system that uses usernames and passwords for user identification. If we instead generalize the *Log In* task into subtasks *Identify myself* and *Prove my identity*, then we have an **essential** task, which admits much richer design possibilities when it's time to translate this task into a user interface.

A danger of concrete task analysis is that it might preserve tasks that are inefficient or could be done a completely different way in software. Suppose we did a task analysis by observing users interacting with paper manuals. We'd see a lot of page flipping: "Find page N" might be an important subtask. We might naively conclude from this that an online manual should provide really good mechanisms for paging & scrolling, and that we should



Hints for Better User & Task Analysis

- Questions to ask
  - Why do you do this? (goal)
  - How do you do it? (subtasks)
- Look for weaknesses in current situation
  - Goal failures, wasted time, user irritation
- Contextual inquiry
- Participatory design

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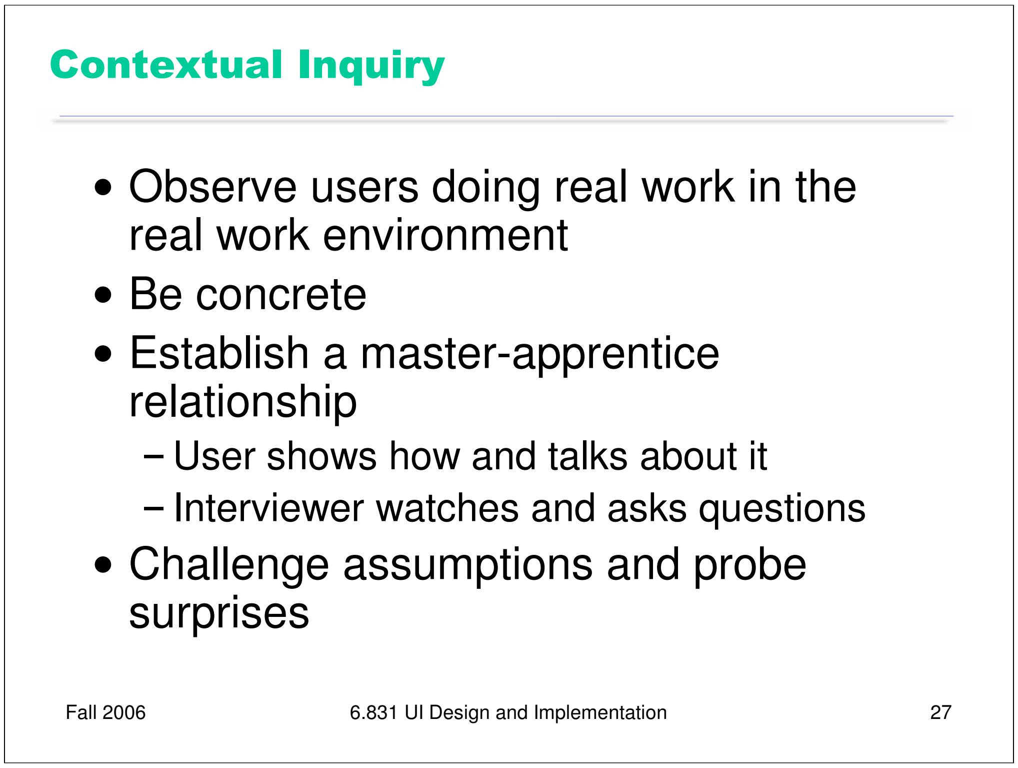
When you're interviewing users, they tend to focus on the what: "first I do this, then I do this…" Be sure to probe for the **why** and **how** as well, to make your analysis more abstract and at the same time more detailed.

Since you want to improve the current situation, look for its weaknesses and problems. What tasks often fail? What unimportant tasks are wasting lots of time? It helps to ask the users what annoys them and what suggestions they have for improvement.

There are two other techniques for making user and task analysis more effective: contextual inquiry and participatory design.



Contextual Inquiry

- Observe users doing real work in the real work environment
- Be concrete
- Establish a master-apprentice relationship
  - User shows how and talks about it
  - Interviewer watches and asks questions
- Challenge assumptions and probe surprises

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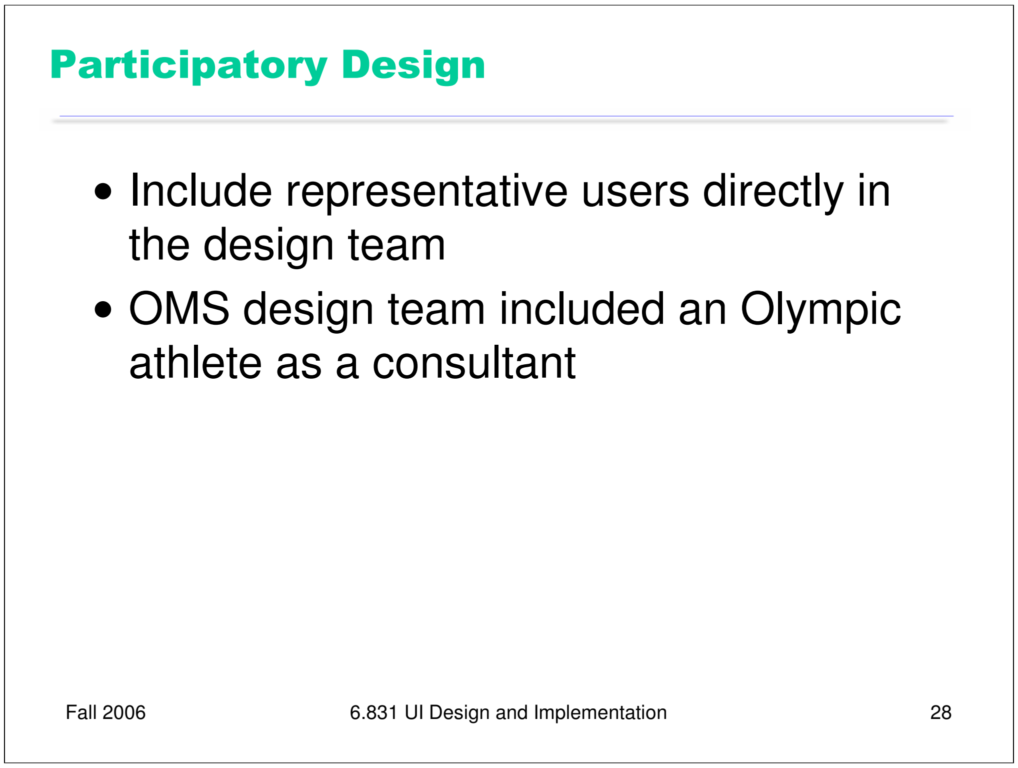
Contextual inquiry is a technique that combines interviewing and observation, in the user's actual work environment, discussing actual work products. Contextual inquiry fosters strong collaboration between the designers and the users. (Wixon, Holtzblatt & Knox, "Contextual design: an emergent view of system design", CHI '90)



Participatory Design

- Include representative users directly in the design team
- OMS design team included an Olympic athlete as a consultant

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Participatory design includes users directly on the design team – participating in the task analysis, proposing design ideas, helping with evaluation. This is particularly vital when the target users have much deeper domain knowledge than the design team. It would be unwise to build an interface for stock trading without an expert in stock trading on the team, for example.