I. Introduction

Importance of Information Technology (IT)
Information Systems and Organizations
What is an Information System?
What is Information System Analysis?
What is Information System Design?
Roles and Tasks for the Information Systems Analyst
Notations, Methodologies and Tools

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Information Everywhere!

…As of 5 years ago…

- North American business generates over 1 billion documents per day.
- Managing these documents can cost up to 10% of a company's revenues and take up to 60% of its time.
- Knowledge workers spend 15-40% seeking and gathering information.
- 3% of all documents are misfiled; it costs, on average, over $200 to recover a misfiled document.
- The average business document is copied 19 times during its lifetime.
- Today's executives spend, on average, about 4 weeks per year waiting for documents to be located.
- Only 10% of corporate information was in computers (i.e., in databases, files,word processors,...)

All these statistics are changing rapidly, thanks to the Information Revolution!

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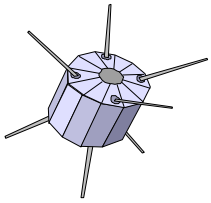
The Information Revolution is Here!

- ☺ Spearheaded by advances in communications, hardware and software
- ☺ Its impact is felt by organizations -- because it affects their way of doing business -- and individuals -- because it affects in profound ways everyday life.
- ☺ Over the next 20 years, we will move from a situation where most of the information we use was on paper or in people's heads, to one where most information is computerized.
- ☺ Moreover, there will be 1-2 orders of magnitude more information than we have available now.



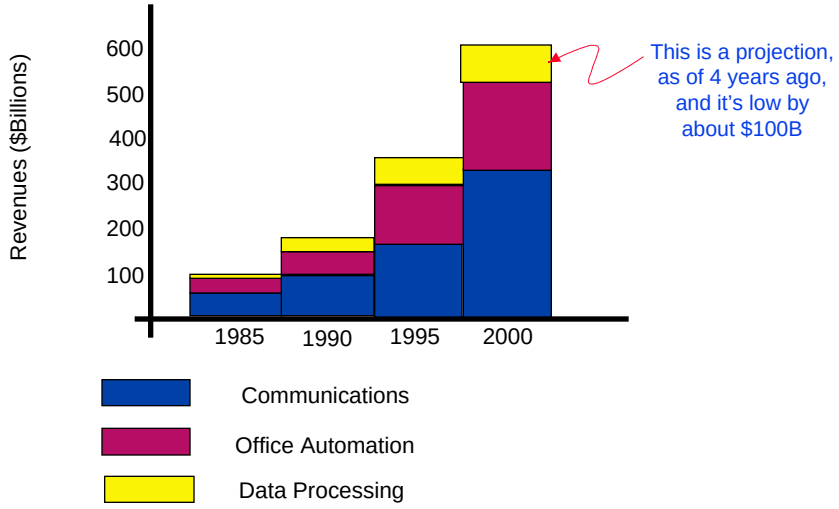
Coping with the Information Revolution

"...there is a very widely shared view that intelligent use of information technology will be the key differentiator for the US (both DoD and corporate) in the future..."

...a technologist…

- Organizations are increasing their budgets for **information services**, i.e., **information systems** and **information specialists.**
- Much emphasis on technology; the size of the Information Technology (IT) market is ~$700/yr in the US alone.
- Worldwide spending on IT is ~$2.1TUS.
- IT accounts for 6.6% of GDP worldwide; it's 9% in the US.
- Systems analyst jobs grew by ~30% between 1985 and 2000; during the same period, overall job market grew by ~15%

Size of the IT Industry (USA)



The Good News

- ☺ Many jobs available under labels such as **systems analyst**, **database administrator**, **applications programmer**, **information officer**,...
- ☺ List of employers offering such jobs includes management consulting companies -- who sell consulting, development and maintenance services -- and large organizations such as banks, utilities, telephone companies, government departments,... who run and depend on information services.
- ☺ Most IT jobs are with small companies -- the majority of the ~10,000 Canadian software companies are in application development or other information system-related areas.

The Bad News

- ☹ 30% of large IT projects are cancelled before completion
- ☹ 50% of IT projects are overbudget by more than 200%
- ☹ The majority of completed projects deliver 60% or less of prescribed functionality
- ☹ Many delivered information systems are under-used because they don't meet user needs and/or expectations
- ☹ Legacy systems are a serious and growing bottleneck to organizational evolution

etc.

Information Technology is failing us!

Why is this Course Important?

- Most errors (54%) are detected after coding and testing.
- Almost half of all errors in software (45%) are in requirements and design.
- Most errors made during requirements analysis are non-clerical (77%) and may arise because of incorrect facts, inconsistencies, omissions and ambiguities.
- Requirements errors can cost up to 100 times more to fix -- if they are not caught early on -- than implementation errors.
- Requirements errors can be detected, because inspection techniques have proven most effective for any software, and inspection techniques can be applied to requirements as well as design and code.

Information in Organizations

- Organizations produce and access ever-growing amounts of information.
- For example, a telecommunications company maintains information on each customer (address, installation data, equipment rented), each account (billing, balance, past history), each call (type, who called, when, for how long,...), each piece of equipment (including telephone lines), each reported problem (type, who handled it,...)
- A power utility maintains information on its generating plants (schematic, equipment, failures, personnel,...), power generation (what was produced when), distribution (who consumed what, when,...), customers,...

Large organizations spend hundereds of millions of dollars handling this information
More often than not, this handling is inadequate and/or unsatisfactory to the organization!

Information Systems and Organizations

Organizational Information Systems consist of an (usually large) **information base** which includes one or more information sources, along with a collection of **processes**, which are carried out by humans and/or machines) for accessing, updating and processing information.

Example: A library -- Information base: books, book catalogues; processes: finding a book, loaning a book, returning a book,...

Example: A student record system -- Information base: student records; Processes: creating, archiving a student record, updating a student record, fetching a student record, recording new registration, course enrolments, course marks,...

Computerized Information Systems

(Computerized) Information Systems consist of one or several databases or files storing an information base, one or more **applications programs** for computer-based access and update of the information base, and one or more **user interfaces** for different user groups;

We focus in this course on computerized information systems built to improve an organizational information system

What is an Information System? The Traditional View

Information System =
Information Base(s) + Applications + Interfaces

- Information bases developed through File, Database or Web technology, using DBMSs, file, database and website design methodologies and tools.
- Applications developed in terms of programming languages, fourth generation languages (4GLs), using programming methodologies such as structured or object-oriented programming, and corresponding tools.
- Interfaces for end-users and other systems developed in terms of generic programming tools (such as compilers), or, more recently, in terms of other sets of specialized tools (HCI tools and data servers)

Examplesof Information Systems

Examples: Systems for: airline reservations (e.g., SABRE), employee administration (e.g., payroll, benefits, project management), banking (accounts, check cashing), manufacturing (e.g., production control, inventory), financial services (e.g., VISA, AmEx, telephone calls), transportation (e.g., registration, violation/citation management, taxes/excise), telephones (e.g., customer accounts, telephone call routing, 800-number support, telephone directory production, facilities management), distribution (e.g., Federal Express package routing and tracking system), environmental management (e.g., air quality, crop usage, pollution monitoring of bodies of water), engineering Information systems (e.g., incorporating Computer Aided Design and other engineering support).

Non-Examples: Systems for: simulation (e.g., of train systems); stand-alone, single user expert systems; robotic systems; scientific computing; systems software (e.g., operating systems, presentation managers, GUIs, utilities); office automation software (text editors, e-mail, drawing packages), software engineering support (development environments and all their tools without a shared, persistent information base); compilers.

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What is an Information System?

- A software system that supports **Data Processing (DP)** i.e., can store, manage and process large amounts of information for routine business transactions, e.g., a bank customer account system.
- An information system may also support one or more of the following functions:
  - ✓ Information Management (MISs) -- provide periodic reports for planning, control and decision making, e.g., generate end-of-the-month reports showing new accounts, transaction volume etc.
  - ✓ Decision Support (DSSs) -- provide information on demand, e.g., an on-line system that combines a spreadsheet with a database to help executives draw up a new budget.
  - ✓ Expert Systems (ESs) -- capture expertise of decision makers in interpreting information or solving problems and serve as assistants to the users of an information system

    e.g., a system that offers advise to a loan manager.

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Example: System X

System X, owned and operated by a large telephone company, is 17 years old, runs on an old, now unique platform under an old, specialized operating system on which the applications depend heavily. It consists of approximately 750,000 lines of largely FORTRAN code.

There are up to 7 versions in production and multiple versions in development. Data and code are tightly interdependent and are not modular making decomposition and redesign difficult or impossible. Data structures, indexes, etc. have evolved without a global design to meet hard functionality and performance requirements. It has many large files (i.e., 1.2 M files with 8.5 M file pages x 1,240 bytes/page] and grows 20% per year in data volume, processing, and accesses. It is used on-line 24 hours per day. Service cannot be interrupted without significant negative impact on the corporation.

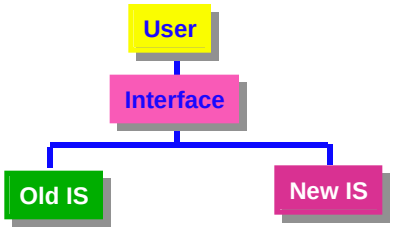
Enhancements and new requirements are constantly requested, faster than they can be understood or accommodated. There is no understanding about the negative impact of massive change (e.g., 60% of System X's functions were never anticipated during its design and construction). There is no complete specification or documentation. Documentation of the old system is inadequate since changes are requested so quickly and so often that the requirements, specification, and documentation cannot (were/are not) kept up to date. The system itself is the only complete description.

System X: Challenges

- Enhanced interoperability and integration with existing and new systems.
- Safe, efficient transactions over System X and its related systems, written in a single, high level language.
- Re-architect System X and its related systems into a future corporate wide information processing architecture (Enterprise Networking Architecture).
- Provide a single, intelligent interface for human users to access functionality of System X and related systems, from a single terminal type anywhere in the corporation.
- Evolve and enhance functionality to meet growing user and corporate demands.
- Changes to a mission critical IS impact other mission critical ISs, hence, related changes must be identified and managed.
- Add maintenance changes and enhancements while the system is operational without disruption of service.
- Embed a significantly altered or new IS into the existing environment.
- Potentially replace the old IS with a new, up-to-date IS.
- Adequately (re)document the system
- Augment the system with automated intelligence functions to make it work better, more efficiently, and live longer and address some of the above problems.

System X: Potential Solutions

- Incrementally, create one or more new ISs to replace parts of old IS; Make changes transparent to users and systems that use or interconnect to old IS by some interface



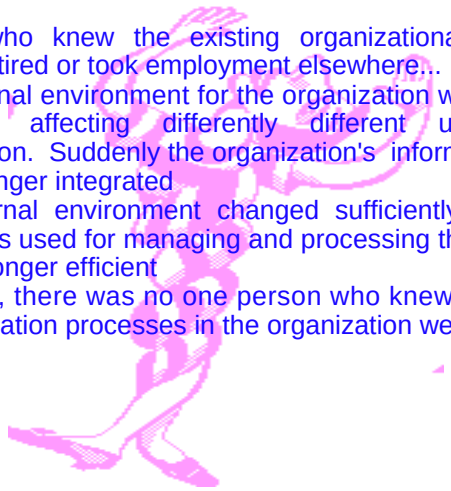
- Keep old IS fully operational, including the components that are replaced with new ISs since it is impossible to understand the complex interdependencies between the replaced components and the rest of the old IS.
- (Sometime later…) Have the new IS completely take over from the old IS. Stop all enhancements to old IS and direct them to new IS.

The Need for Systems Analysis: The Age of Innocence

- Once upon a time, the information processes in an organization were simple and small - easy to handle with one or two people
- As the organization grew, it took on additional tasks and had to handle information about more people or things important to the organization, for example, statistical data on production and sales, design data, financial data etc.
- As the organization grew, the **information workers** within the organization learned their information management tasks (classification, reference) well enough to add on more complex tasks
- As the organization grew, it split into subunits to facilitate management, but this often acted as a barrier to information flow. Still, there was one organizational information system
- As the organization evolved, so did its organizational information system, but this evolution was not documented

The Need for Systems Analysis: Fall from Eden

- People who knew the existing organizational information system retired or took employment elsewhere...
- The external environment for the organization was constantly changing, affecting differently different units in the organization. Suddenly the organization's information system was no longer integrated
- The external environment changed sufficiently so that the techniques used for managing and processing the information were no longer efficient
- Suddenly, there was no one person who knew exactly what the information processes in the organization were all about



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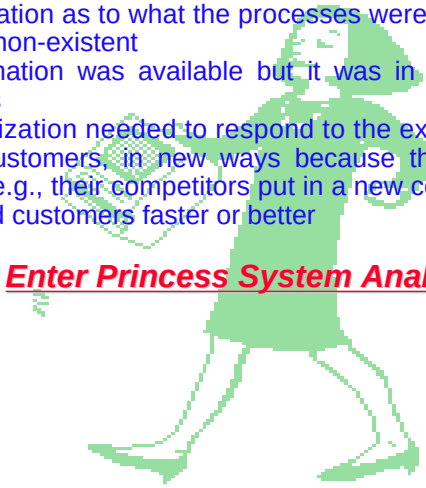
The Need for Systems Analysis: Fall from Eden

- Documentation as to what the processes were was completely out of date or non-existent
- The information was available but it was in the heads of many employees
- The organization needed to respond to the external environment, e.g., its customers, in new ways because the environment had changed, e.g., their competitors put in a new computerized system that served customers faster or better

Enter Princess System Analysis!



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What is (Information) Systems Analysis?

- The collection of notations, methodologies and tools used to gather details and analyze a problem situation prior to information system design and implementation
- Systems analysis must ensure that the proposed information system meets the user's needs, can be delivered on time, and can be updated inexpensively.
- Problems in "getting the systems analysis right", such as Ill-defined situations, ambiguities, inconsistencies, mixing requirements with design

Finding and fixing a fault after software delivery
is 100 more expensive
than finding and fixing it
during systems analysis or early design phases

What is the Result of Systems Analysis?

- The result of an information system analysis is a **requirements definition** (or, "requirements")
  - How is a requirements definition used?
    - As a statement of the problem to be solved
    - For communication between designer and end-users
    - To support information system evolution
    - To support design validation
- What goes in a requirements definition?
  - **Functional requirements**: What does the system do? What information is maintained? What activities are carried out? What interfaces are supported?
  - **Non-functional requirements**: Global constraints on the system, such as performance constraints, (resource constraints, security, reliability,..)., operational constraints (hardware requirements, personnel,...), life cycle constraints etc.

What is System Design?

The specification of the information system to be built. This specification includes:

- The **hardware configuration** on which the system will run, including network interfaces.
- The **software platform** on which the system will run, i.e., operating system, DBMS, programming language, etc...
- The **software architecture** of the proposed system, including interfaces between the system modules.
- The **function** of each module, i.e., what does each module do, I.e., transformations it performs on its inputs.
- The **database(s)** that will be part of the information system, stored in database management systems (DBMSs) or in files
- **User interfaces** that need to be in place to facilitate use of the system by different user groups

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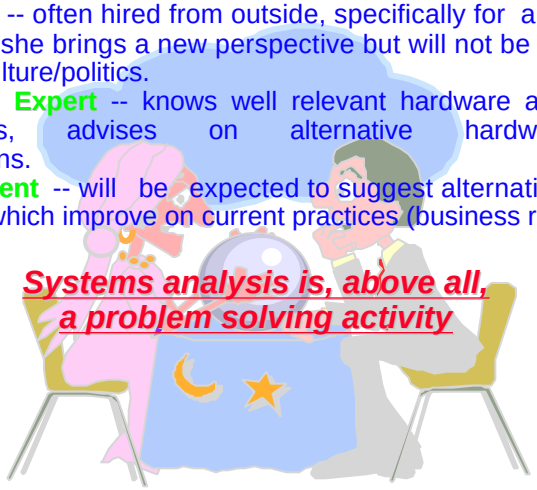
Roles of the Systems Analyst

- **Consultant** -- often hired from outside, specifically for a project; this means that she brings a new perspective but will not be familiar with company culture/politics.
- **Supporting Expert** -- knows well relevant hardware and software technologies, advises on alternative hardware/software configurations.
- **Change Agent** -- will be expected to suggest alternative business processes which improve on current practices (business reengineer).



Systems analysis is, above all, a problem solving activity

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The Task of Information Systems Analysis: Define a Problem and Find a Solution

To figure out what an organizational information system is like, so that:

- This system can be made more efficient
- The system can take advantage of the speed, processing capacity and memory of computers to carry out or support its information processes
- The system can take advantage of electronic communication to improve communication between various divisions of the organization
- The system can provide new services
- The system can integrate several operations

The Tasks of the Systems Analyst

Interviews individuals who offer, use or manage information processing services for the organization in order to find out:

- What information processes and procedures are perform/needed within the organization
- What information is being maintained
- What needs do users have?

Learns about the nature of the business of the organization and its goals in order to:

- Recommend computer changes that will help the organization to better achieve its goals
- Understand the nature and reasons for the information processing tasks that are done by members of the organization.

System Analyst has to be good at "ignorance hiding"

The Tasks of the Systems Analyst

- **Recommends** software, hardware and communication equipment purchases for the organization to support its information processing systems
- **Builds** a graphical representation of any existing information system -- Requirements Analysis
- **Uses** the representation of the existing system to define requirements for a new system -- Requirements Analysis
- Based on the requirements document, designs a new system -- Systems Design
- **Specifies** the format of the data files, of the data entry screens and of the reports generated by the information systems
- **Specifies** the human processing procedures for the new information system
- **Specifies** the programs to be developed or purchased for the new information system and the security and control procedures that need to be in place.
- **Monitors** the development and installation of the new information system and the effectiveness of the new system

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The Pitfalls of Systems Analysis: A Tale

Once upon a time, in a kingdom not far from here, a king summoned two of his advisors for a test. He showed them both a shiny metal box with two slots in the top, a control knob, and a lever. "What do you think this is?"

One advisor, an engineer, answered first. "It is a toaster," he said. The king asked, "How would you design an embedded computer for it?" The engineer replied, "Using a four-bit microcontroller, I would write a simple program that reads the darkness knob and quantizes its position to one of 16 shades of darkness, from snow white to coal black. The program would use that darkness level as the index to a 16-element table of initial timer values. Then it would turn on the heating elements and start the timer with the initial value selected from the table. At the end of the time delay, it would turn off the heat and pop up the toast. Come back next week, and I'll show you a working prototype."

The second advisor, a computer scientist, immediately recognized the danger of such short-sighted thinking. He said, "Toasters don't just turn bread into toast, they are also used to warm frozen waffles. What you see before you is really a breakfast food cooker. As the subjects of your kingdom become more sophisticated, they will demand more capabilities. They will need a breakfast food cooker that can also cook sausage, fry bacon, and make scrambled eggs. A toaster that only makes toast will soon be obsolete. If we don't look to the future, we will have to completely redesign the toaster in just a few years."

"With this in mind, we can formulate a more intelligent solution to the problem. First, create a class of breakfast foods. Specialize this class into subclasses: grains, pork, and poultry. The specialization process should be repeated with grains divided into toast, muffins, pancakes, and waffles; pork divided into sausage, links, and bacon; and poultry divided into scrambled eggs, hard-boiled eggs, poached eggs, fried eggs, and various omelet classes."

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"...The ham and cheese omelet class is worth special attention because it must inherit characteristics from the pork, dairy, and poultry classes. Thus, we see that the problem cannot be properly solved without multiple inheritance. At run time, the program must create the proper object and send a message to the object that says, 'Cook yourself.' The semantics of this message depend, of course, on the kind of object, so they have a different meaning to a piece of toast than to scrambled eggs."

"Reviewing the process so far, we see that the analysis phase has revealed that the primary requirement is to cook any kind of breakfast food. In the design phase, we have discovered some derived requirements. Specifically, we need an object-oriented language with multiple inheritance. Of course, users don't want the eggs to get cold while the bacon is frying, so concurrent processing is required, too."

"We must not forget the user interface. The lever that lowers the food lacks versatility, and the darkness knob is confusing. Users won't buy the product unless it has a user-friendly, graphical interface. When the breakfast cooker is plugged in, users should see a cowboy boot on the screen. Users click on it, and the message 'Booting UNIX v. 8.3' appears on the screen. (UNIX 8.3 should be out by the time the product gets to the market.) Users can pull down a menu and click on the foods they want to cook."

"Having made the wise decision of specifying the software first in the design phase, all that remains is to pick an adequate hardware platform for the implementation phase. An Intel 80386 with 8MB of memory, a 30MB hard disk, and a VGA monitor should be sufficient. If you select a multitasking, object oriented language that supports multiple inheritance and has a built-in GUI, writing the program will be a snap. (Imagine the difficulty we would have had if we had foolishly allowed a hardware-first design strategy to lock us into a four-bit microcontroller!)."

The king wisely had the computer scientist beheaded, and they all lived happily ever after.

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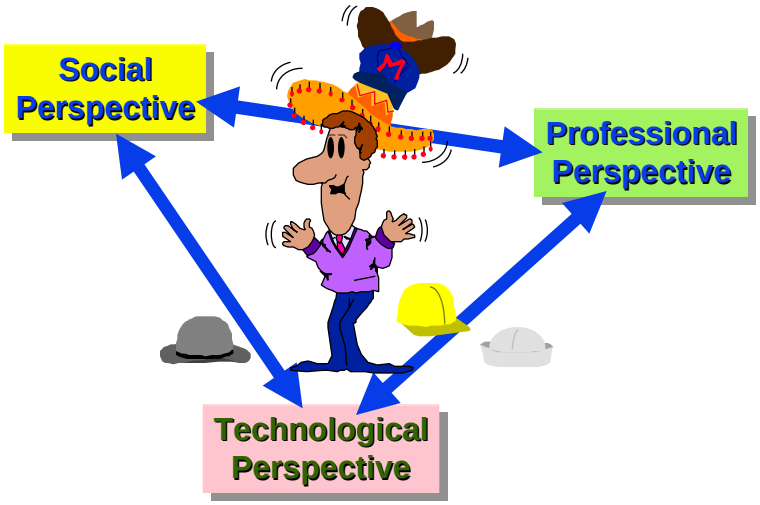
The Background of the Systems Analyst



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The Three Perspectives

- **Technological perspective** -- IT tools, such as hardware, computer networks, databases, compilers, CASE tools,...and methods for using them.
- **Social perspective** -- applied sociology, anthropology, psychology etc., looking at issues such as: how do individuals and organizations use information, how are they affected by increased availability of information,...
- **Professional perspective** -- professional practices and standards in performing information service-related tasks, such as communication protocol standards, software standards, government policies on privacy, security, accuracy etc. of information, professional standards on information acquisition, cataloguing, selection,...

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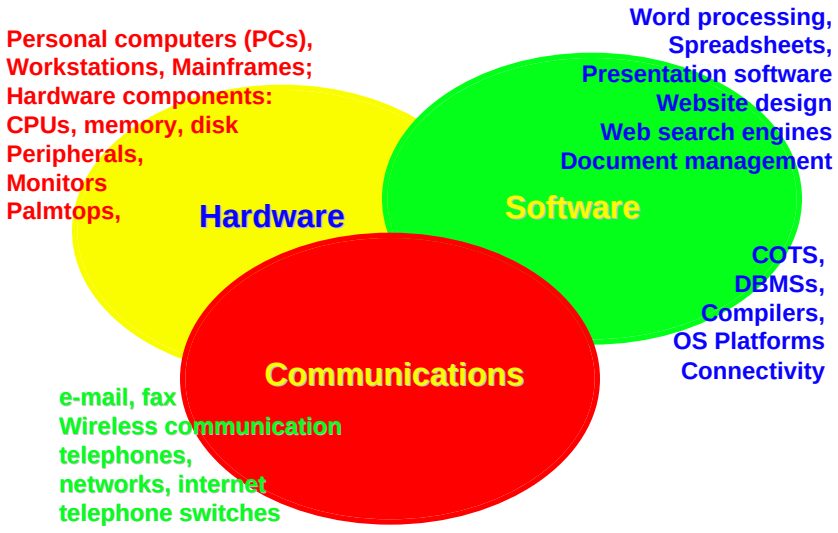
Technologies for System Analysis



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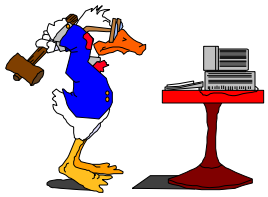
Trends

- Hardware, connectivity, portability increasingly taken for granted.
- Less emphasis on implementation, more emphasis on design and analysis, for **work processes** and **information services**, not just information systems!
- Greater demand for "people skills" as opposed to "technological skills"
- More packaged applications (Enterprise Resource Planning, or ERP, systems) sold by companies like SAP, PeopleSoft and Oracle.



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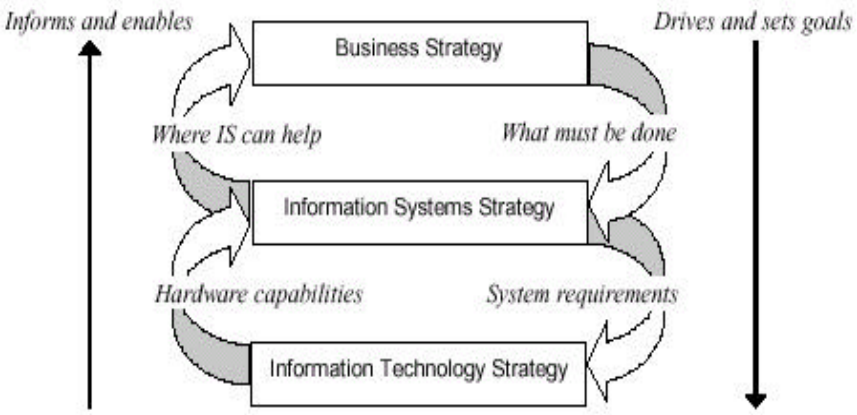
Information Systems and Information Technologies Strategies



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Notations, Methodologies and Tools for Information System Development

Systematic information system development is based on notations, a methodologies and associated tools

- **Notation** -- used to describe the information captured during different phases; notations range from natural language, to diagrammatic notations (such as entity-relationship or data flow diagrams), or formal languages, such as programming languages.
- **Methodology** -- this determines the process whereby the software developer creates, refines, analyzes and validates a software system; methodologies are often project- or situation-specific
- **Tools** -- introduced to support the creation, refinement, analysis and validation of software (such as CASE tools).

Generally, software engineering practice does poorly with respect to all of the above!

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Problems

1. Collect newspaper ads for systems analysis jobs. Compare these to the textbook's description of required skills and job description. Synthesize your own ad and explain its features.

2. Visit your local library and make a list of magazines or newspapers on PCs, data communications, data applications and management issues. Choose one magazine/newspaper in each category and describe the kinds of topics it covers.

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