Software Testing and Maintenance
Designing for Change

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Designing for Maintainability

1. Integrating Software Components
2. Sharing Data and Message Passing
3. Using Design Patterns to Integrate

Modern Software is Connected

- Modern programs rarely live in isolation
  - They interact with other programs on the same computer
  - They use shared library modules
  - They communicate with programs on different computers
  - Data is shared among multiple computing devices
- Web applications communicate across a network
- Web services connect dynamically during execution
- Distributed computing is now common

Why Integration is Hard

- Networks are unreliable
- Networks are slow
  - Multiple orders of magnitude slower than a function call
- Programs on different computers are diverse
  - Different languages, operating systems, data formats, …
  - Connected through diverse hardware and software applications
- Change is inevitable and continuous
  - Programs we connect with change
  - Host hardware and software changes

Distributed software must use extremely low coupling

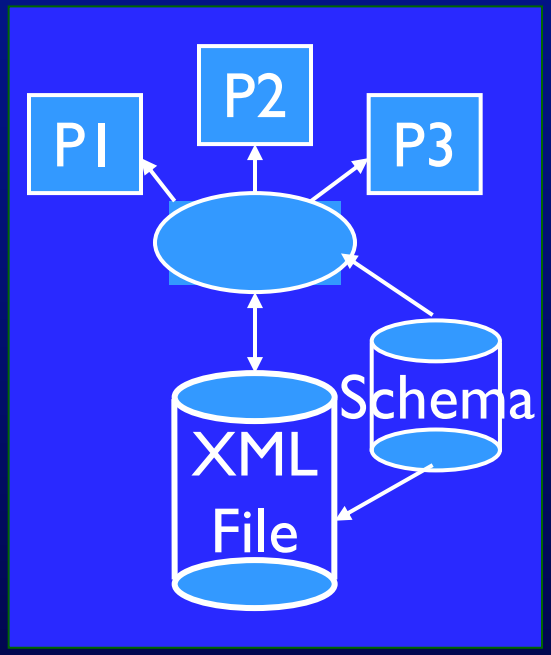
Extremely Loose Coupling

- *Tight Coupling* : Dependencies encoded in logic
  - Changes in A may require changing logic in B
  - This used to be common
- *Loose Coupling* : Dependencies encoded in the structure and data flows
  - Changes in A may require changing data uses in B
  - Goal of data abstraction and object-oriented concepts
- *Extremely Loose Coupling* (*ELC*): Dependencies encoded only in the data contents
  - Changes in A only affects the contents of B's data
  - Motivating goal for distributed software and web applications

The issues are about how we share data …

XML supports Extremely Loose Coupling

- Data is passed directly between components
- Components must agree on format, types, and structure
- XML allows data to be self-documenting

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- P1, P2, and P3 can see the format, contents, and structure of the data
- Free parsers are available

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General Ways to Share Data

1. Transferring files
   - One program writes to a file that another later reads
   - Both programs need to agree on:
     - File name, location, and format
     - Timing for when to read and write it
2. Sharing a Database
   - Replace a file with a database
   - Most decisions are encapsulated in the table design
3. Remote Procedure Invocation
   - One program calls a method in another application
   - Communication is real-time and synchronous
   - Data are passed as parameters
4. Message Passing
   - One program sends a message to a common message channel
   - Other programs read the messages at a later time
   - Programs must agree on the channel and message format
   - Communication is asynchronous
   - XML is often used to implement to encode messages

Message Passing

Message passing is asynchronous and very loosely coupled

- Telephone calls are *synchronous*
- This introduces restrictions :
  - Other person must be there
  - Communication must be in real-time

- Voice mail is *Asynchronous*
- Messages are left for later retrieval
- Real-time aspects are less important

Benefits of Messaging

- Message-based software is easier to change and reuse
  - Better encapsulated than shared database
  - More immediate than file transfer
  - More reliable than remote procedure invocation
- Software components depend less on each other
- Several engineering advantages:
  - Reliability
  - Maintainability & Changeability
  - Security
  - Scalability

Disadvantages of Messaging

- Programming model is different – and complex
  - Universities seldom teach event-driven software (SWE 432)
  - Logic is distributed across several software components
  - Harder to develop and debug
- Sequencing is harder
  - No guarantees for when messages will arrive
  - Messages sent in one sequence may arrive out of sequence
- Some programs require applications to be synchronized
  - Shopping requires users to wait for responses
  - Most web applications are synchronized
    - Ajax allows asynchronous communication
- Message passing is slower, but good middleware helps

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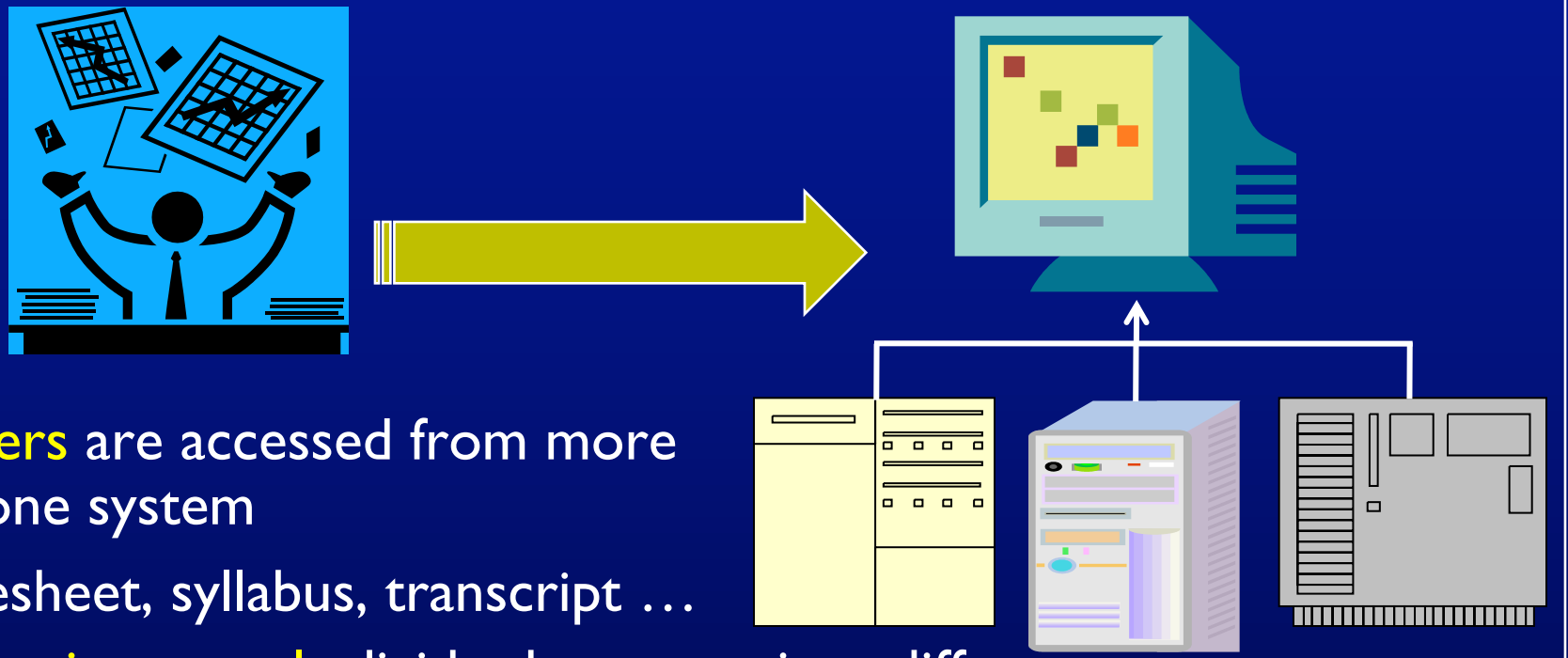
Enterprise Applications

- Enterprise systems contain hundreds or thousands of separate applications
  - Custom-built, third party vendors, legacy systems, …
  - Multiple tiers with different operating systems
- Enterprise systems often *grow* from disjoint pieces
  - Just like a town or city grows together and slowly integrates
- Companies want to buy the best package for each task
  - Then integrate them !

Thus – integrating diverse programs into a coherent enterprise application will be an exciting task for years to come

Information Portals

Information portals aggregate information from multiple sources into a single display to avoid making the user access multiple systems

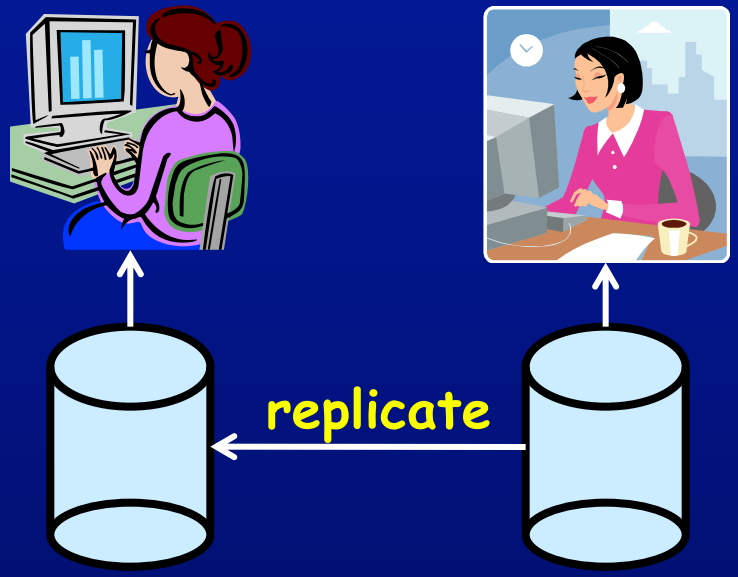


- Answers are accessed from more than one system
- Gradesheet, syllabus, transcript …
- Information portals divide the screen into different zones
- They should ease moving data from one zone to another

Data Replication

Making data that is needed by multiple applications available to all hardware platforms

- Multiple business systems often need the same data
- Student email address is needed by professors, registrar, department, IT, …
- When email is changed in one place, all copies must change

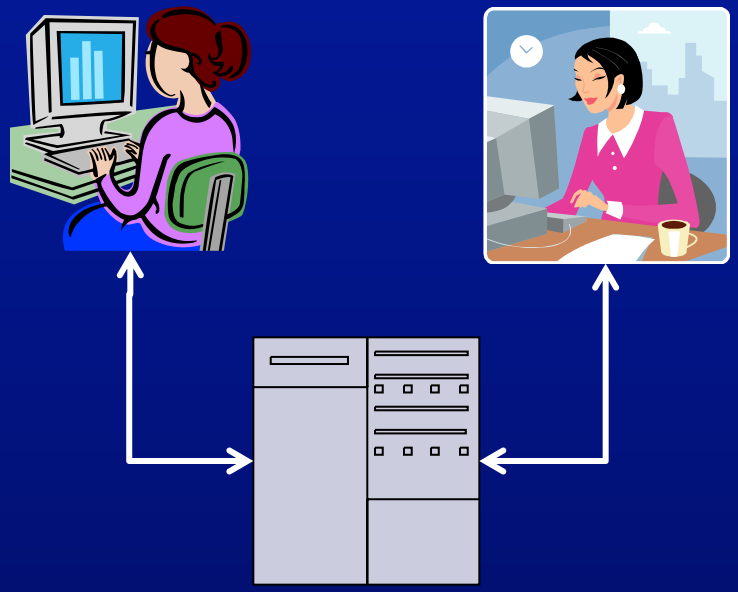


- Data replication can be implemented in many ways
  - Built into the database
  - Export data to files, re-import them to other systems
  - Use message-oriented middleware

Shared Business Functions

Same function used by several applications

- Multiple users need the same function
- Whether a particular course is taught this semester
  - Student, instructor, admins
- Each function should only be implemented once

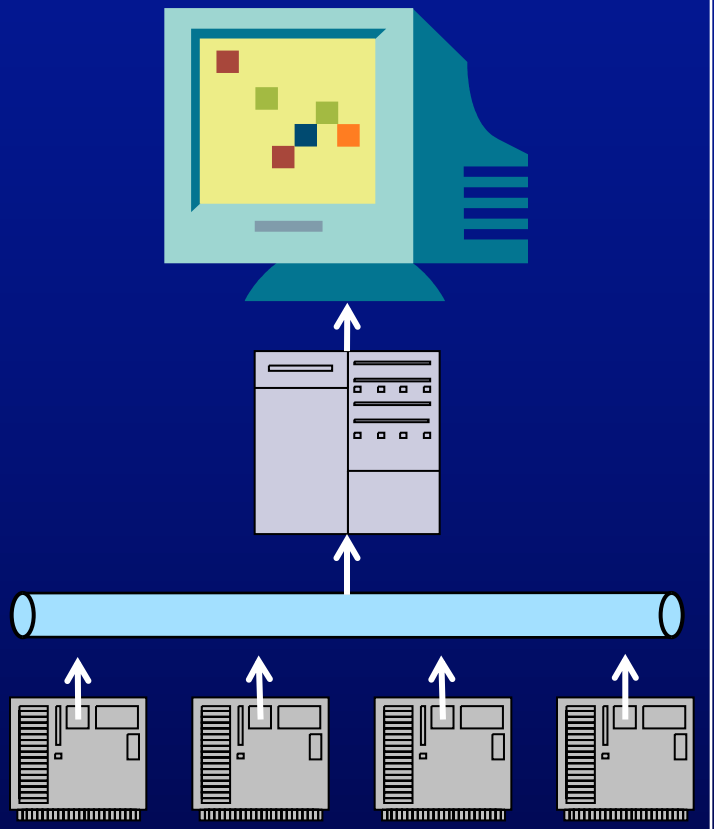


- If the function only accesses data to return result, duplication is simple
- If the function modifies data, race conditions can occur

Service-Oriented Architectures (SOA)

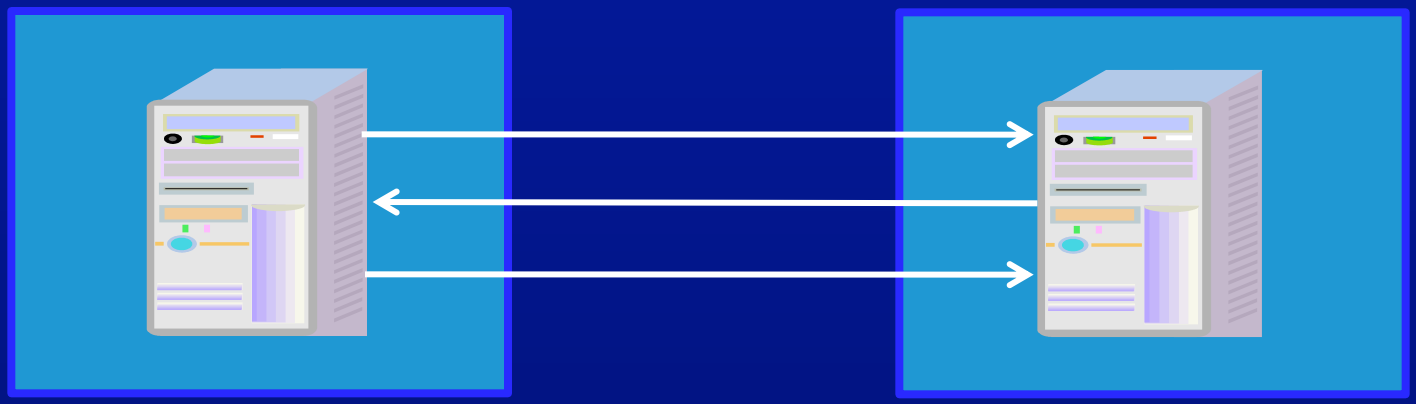
A service is a well-defined function that is universally available and responds to requests from "service consumers"

- Managing a collection of useful services is a critical function
  - A service directory
  - Each service needs to describe its interface in a generic way
- A mixture of integration and distributed application



Business-to-Business Integration

Integration between two separate businesses



- Business functions may be available from outside suppliers or business partners
- Online travel agent may use a credit card service
- Integration may occur "on-the-fly"
  - A customer may seek the cheapest price on a given day
- Standardized data formats are critical

Summary : Coupling, Coupling, Coupling

- We have always known coupling is important
- Goal is to reduce the assumptions about exchanging data
  - Loose coupling means fewer assumptions
- A local method call is very tight coupling
  - Same language, same process, typed parameters, return value
- Remote procedure call has tight coupling, but with the complexity of distributed processing
  - The worst of both worlds
  - Results in systems that are hard to maintain
- Message passing has extremely loose coupling

Message passing systems are easy to maintain