# Software Prototyping

- Rapid software development to validate requirements

# Objectives

- To describe the use of prototypes in different types of development project
- To discuss evolutionary and throw-away prototyping
- To introduce three rapid prototyping techniques - high-level language development, database programming and component reuse
- To explain the need for user interface prototyping

# Topics covered

- Prototyping in the software process
- Prototyping techniques
- User interface prototyping

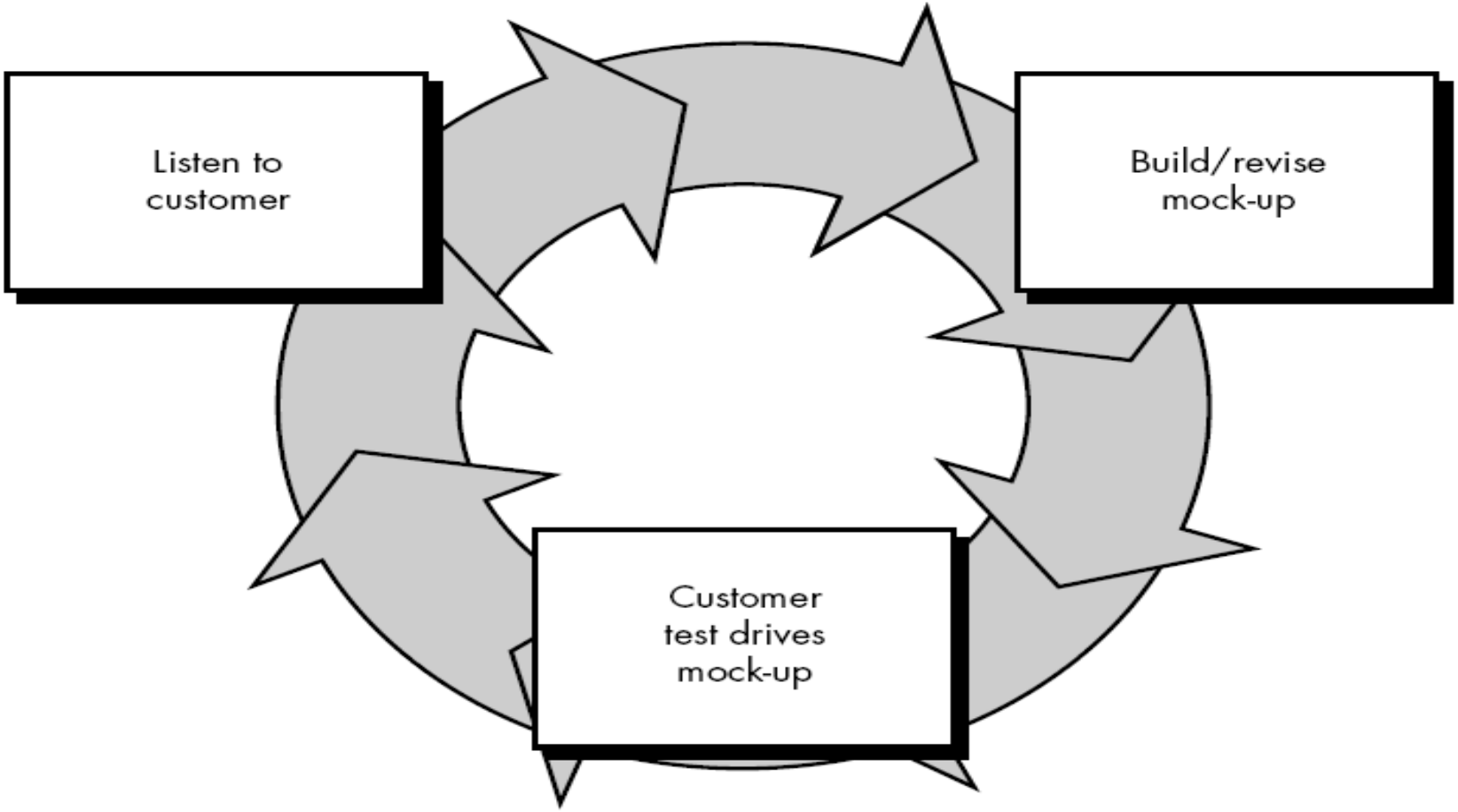
# System prototyping

- **Prototyping is the rapid development of a system**
- In the past, the developed system was normally thought of as inferior in some way to the required system so further development was required
- Now, the boundary between prototyping and normal system development is blurred and many systems are developed using an evolutionary approach

# Prototyping Model

- Developers build a prototype during the requirements phase
- Prototype is evaluated by end users
- Users give corrective feedback
- Developers further refine the prototype
- When the user is satisfied, the prototype code is brought up to the standards needed for a final product.

# Prototyping Paradigm



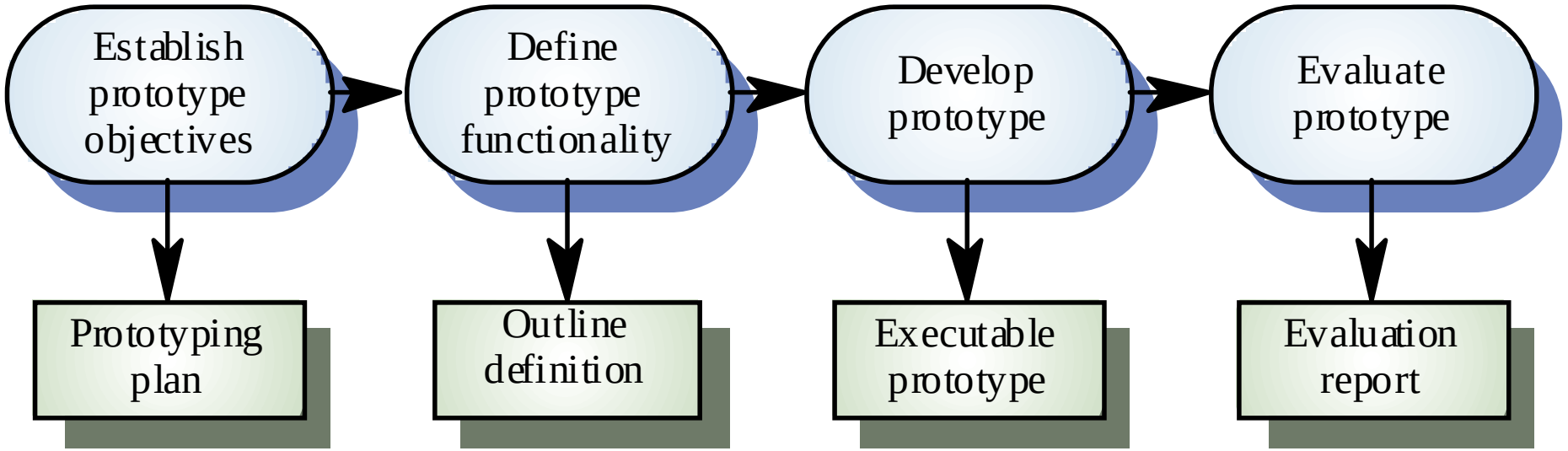
# Uses of system prototypes

- The principal use is to help customers and developers understand the requirements for the system
  - Requirements elicitation. Users can experiment with a prototype to see how the system supports their work
  - Requirements validation. The prototype can reveal errors and omissions in the requirements
- Prototyping can be considered as a risk reduction activity which reduces requirements risks

# Prototyping benefits

- Misunderstandings between software users and developers are exposed
- Missing services may be detected and confusing services may be identified
- A working system is available early in the process
- The prototype may serve as a basis for deriving a system specification
- The system can support user training and system testing

# Prototyping process



# Prototyping benefits

- Improved system usability
- Closer match to the system needed
- Improved design quality
- Improved maintainability
- Reduced overall development effort

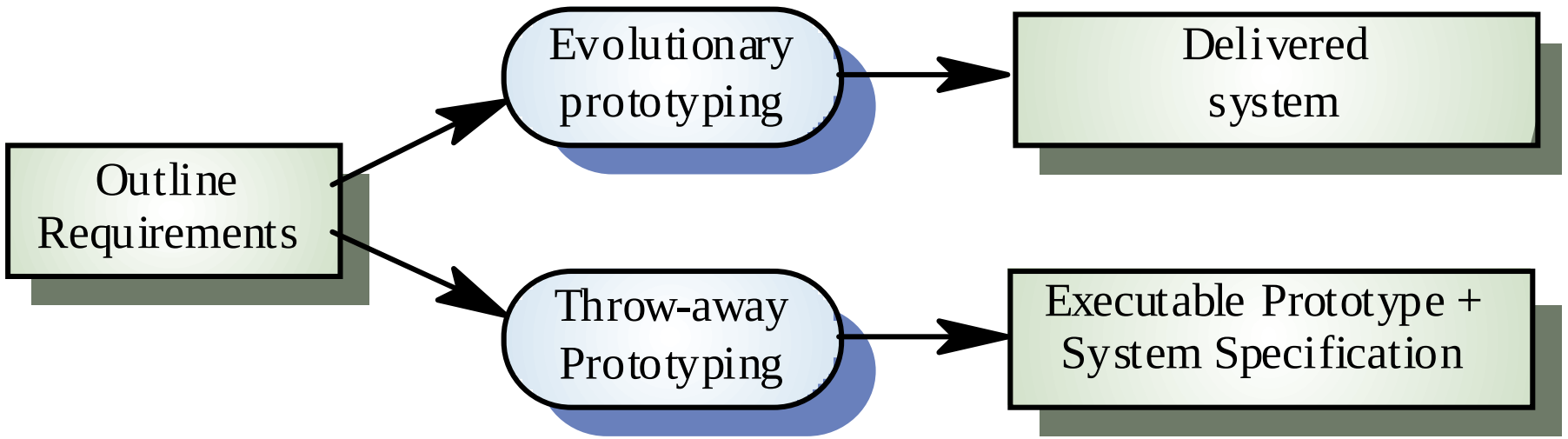
# Prototyping in the software process

- Evolutionary prototyping
  - An approach to system development where an initial prototype is produced and refined through a number of stages to the final system
- Throw-away prototyping
  - A prototype which is usually a practical implementation of the system is produced to help discover requirements problems and then discarded. The system is then developed using some other development process

# Prototyping objectives

- The objective of *evolutionary prototyping* is to deliver a working system to end-users. The development starts with those requirements which are best understood.
- The objective of *throw-away prototyping* is to validate or derive the system requirements. The prototyping process starts with those requirements which are poorly understood

# Approaches to prototyping

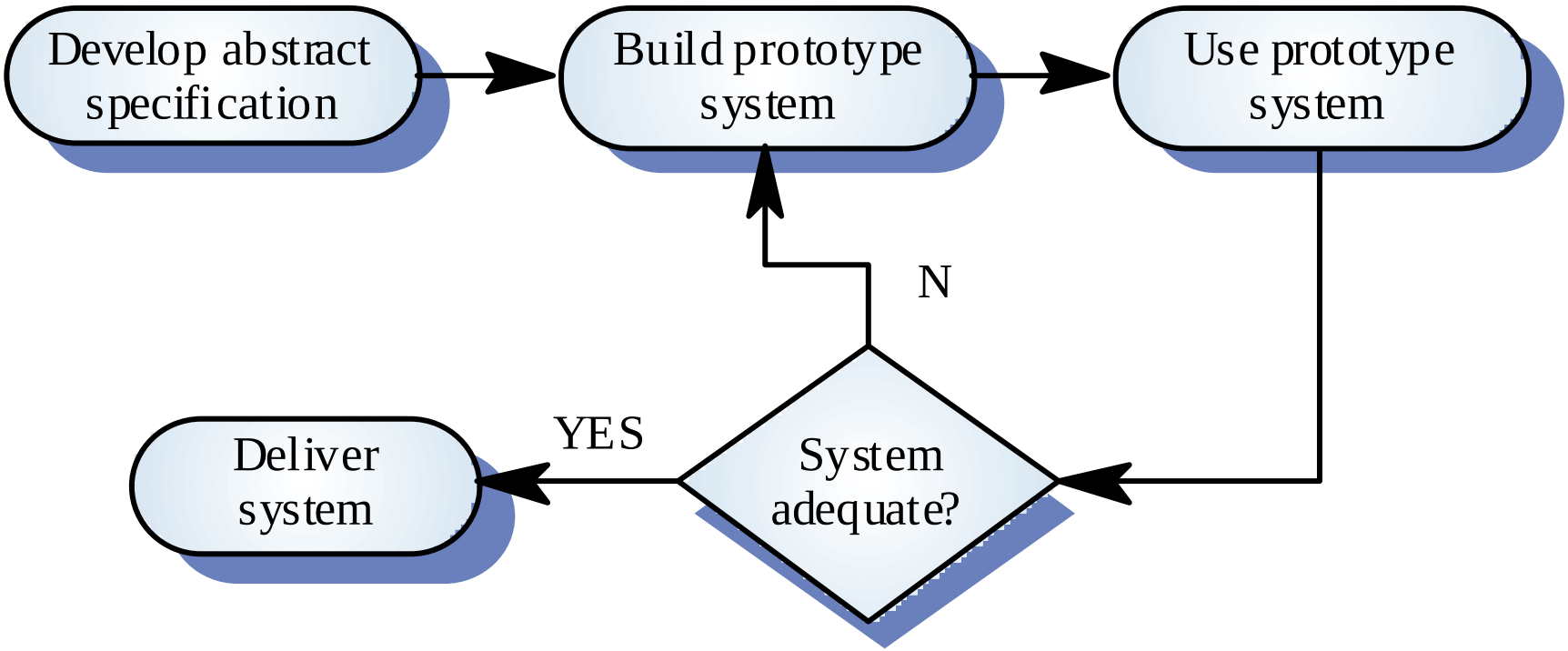


# Evolutionary prototyping

- Must be used for systems where the specification cannot be developed in advance.

  e.g. AI systems and user interface systems
- Based on techniques  allow rapid system iterations
- Verification is impossible as there is no specification. Validation means demonstrating the adequacy of the system

# Evolutionary prototyping

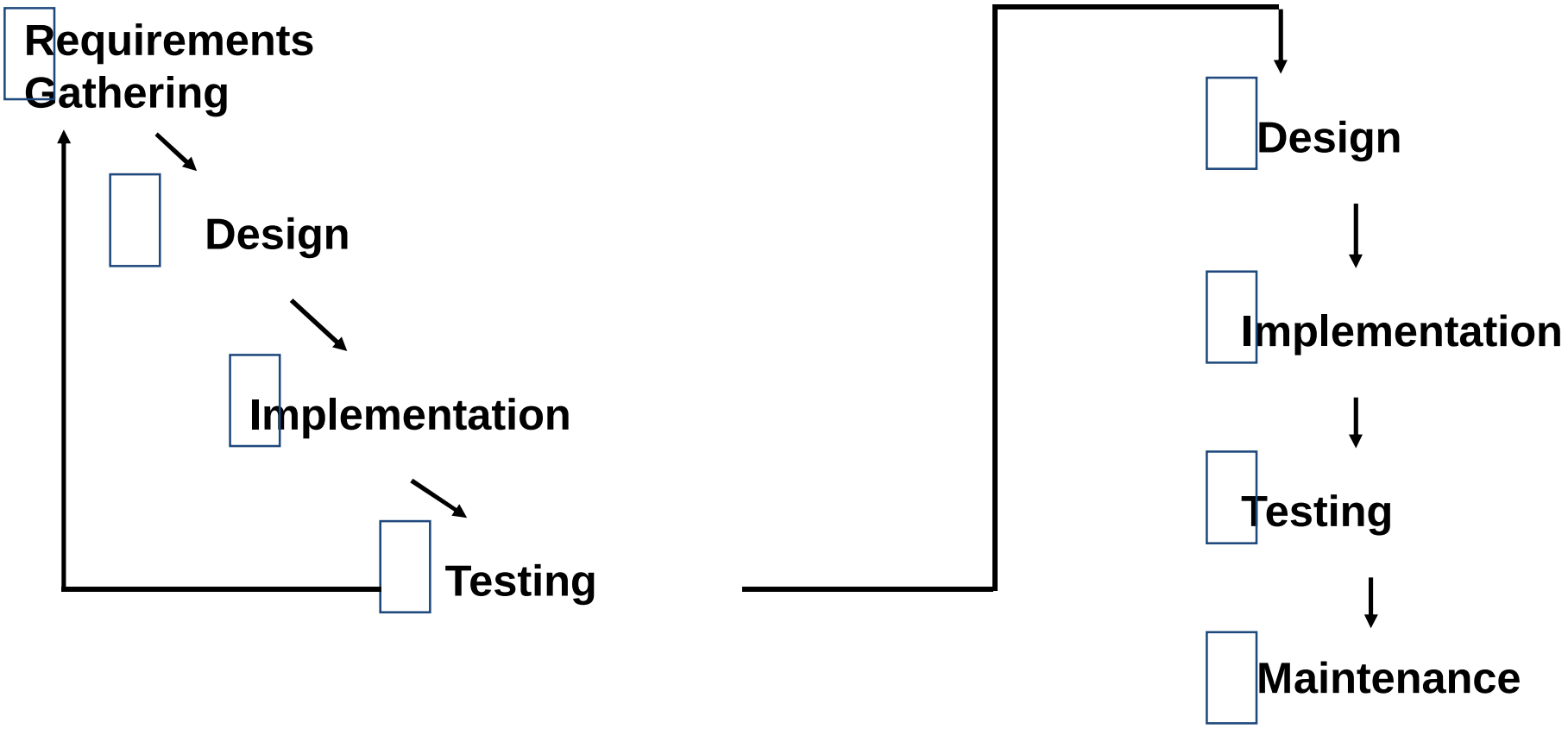


# Evolutionary prototyping advantages

- Accelerated delivery of the system
  - Rapid delivery and deployment are sometimes more important than functionality or long-term software maintainability
- User engagement with the system
  - Not only is the system more likely to meet user requirements, they are more likely to commit to the use of the system

# Evolutionary prototyping

- Specification, design and implementation are inter-twined.
- The system is developed as a series of increments that are delivered to the customer
- Techniques for rapid system development are used such as CASE tools and 4GLs
- User interfaces are usually developed using a GUI development toolkit


Requirements Gathering
Design
Implementation
Testing
Design
Implementation
Testing
Maintenance

# Evolutionary Strength

- Advantages
  - Effort of prototype is not wasted
  - Faster than the waterfall model
  - High level of user involvement from start
  - Technical or other problems discovered early - risk reduced

# Evolutionary prototyping problems

- Management problems
  - Specialist skills are required which may not be available in all development teams
- Maintenance problems
  - Continual change tends to corrupt system structure so long-term maintenance is expensive
  - Other Problems
    - Difficult to plan as amount of effort is uncertain
    - Documentation may be neglected
    - Languages which are good for prototyping not always best for final product

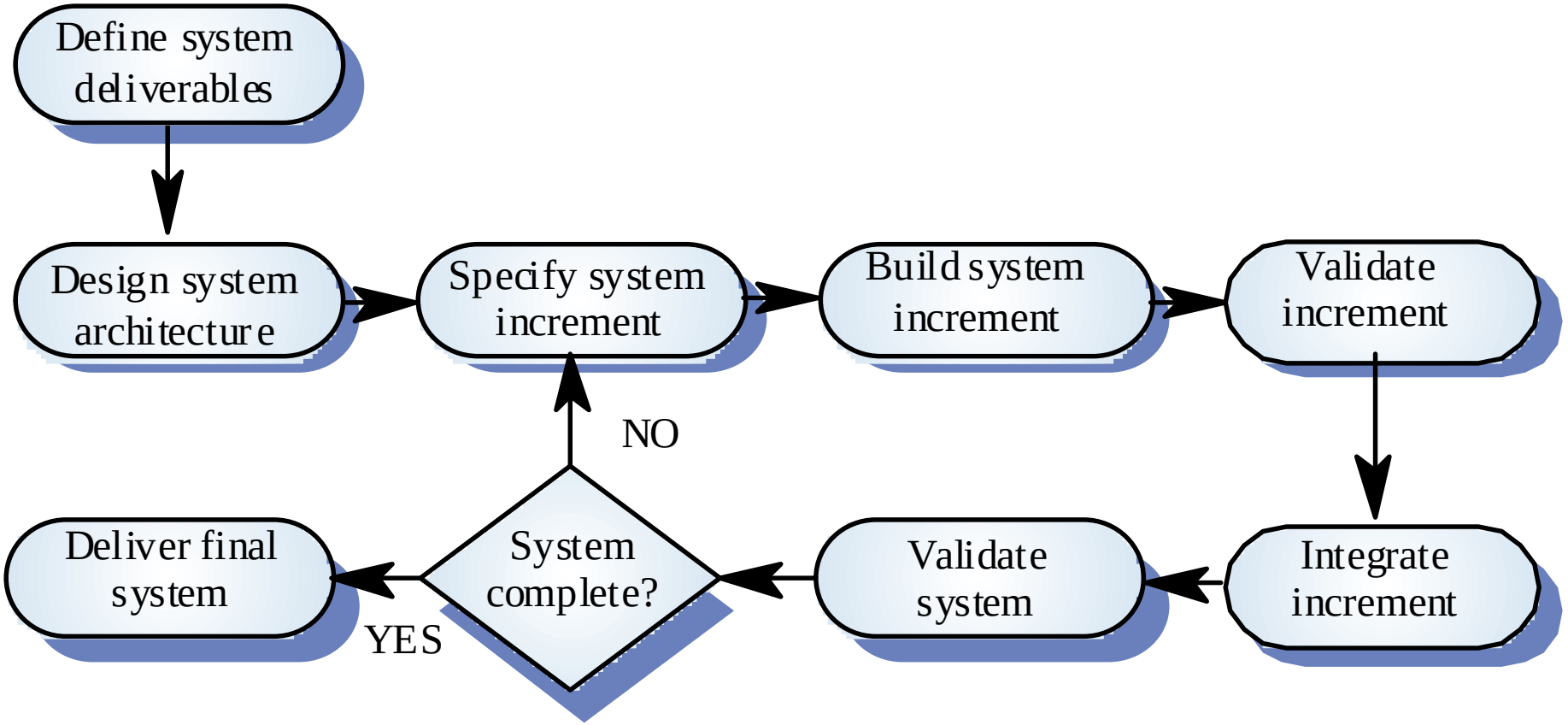
# Prototypes as specifications

- Some parts of the requirements (e.g. safety-critical functions) may be impossible to prototype and so don't appear in the specification
- An implementation has no legal standing as a contract
- Non-functional requirements cannot be adequately tested in a system prototype

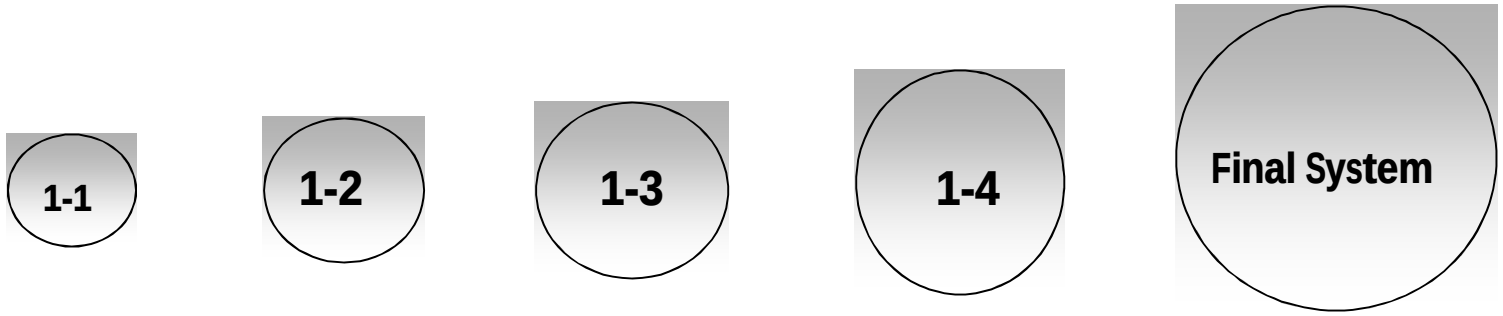
# Incremental development

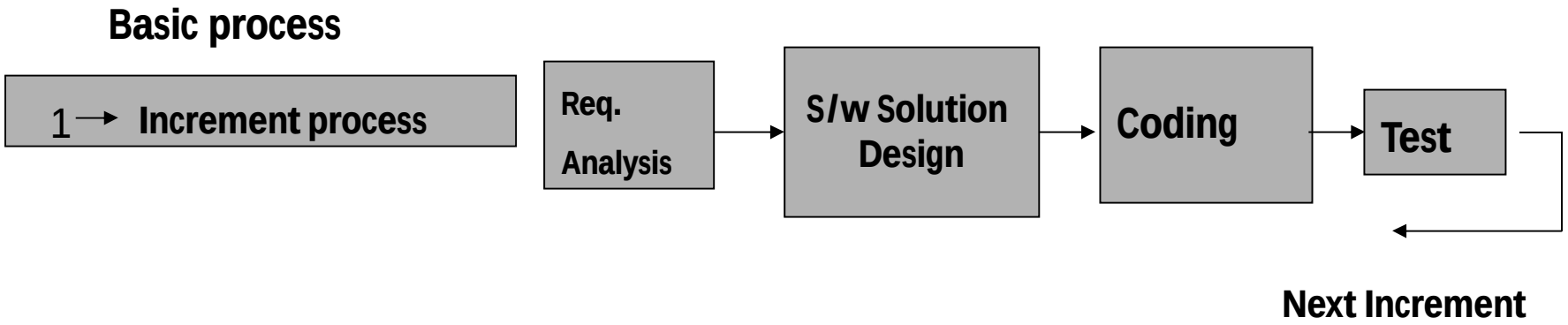
- System is developed and delivered in increments after establishing an overall architecture
- Requirements and specifications for each increment may be developed
- Users may experiment with delivered increments while others are being developed. therefore, these serve as a form of prototype system
- Intended to combine some of the advantages of prototyping but with a more manageable process and better system structure

# Incremental development process

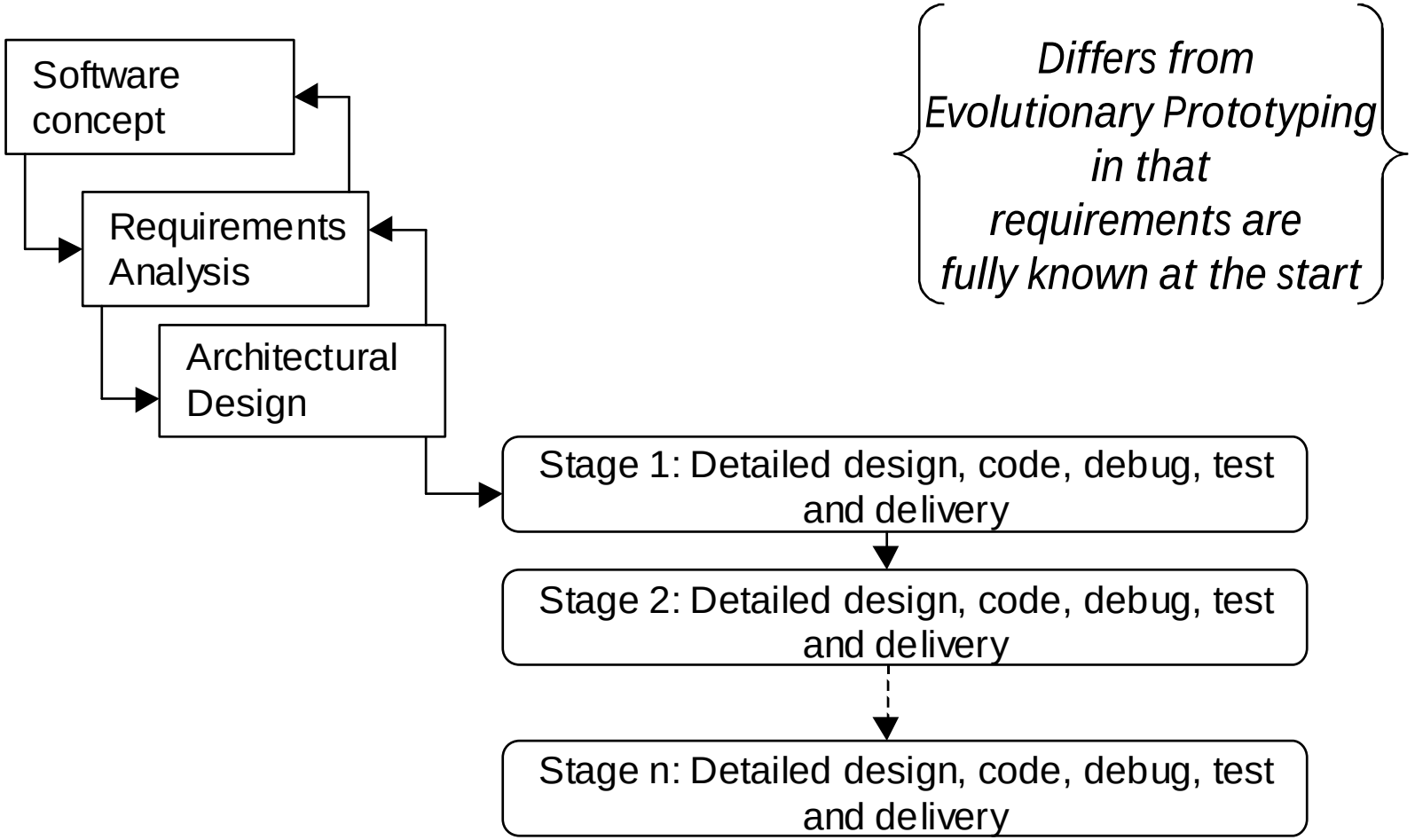


# Incremental Model (INM)

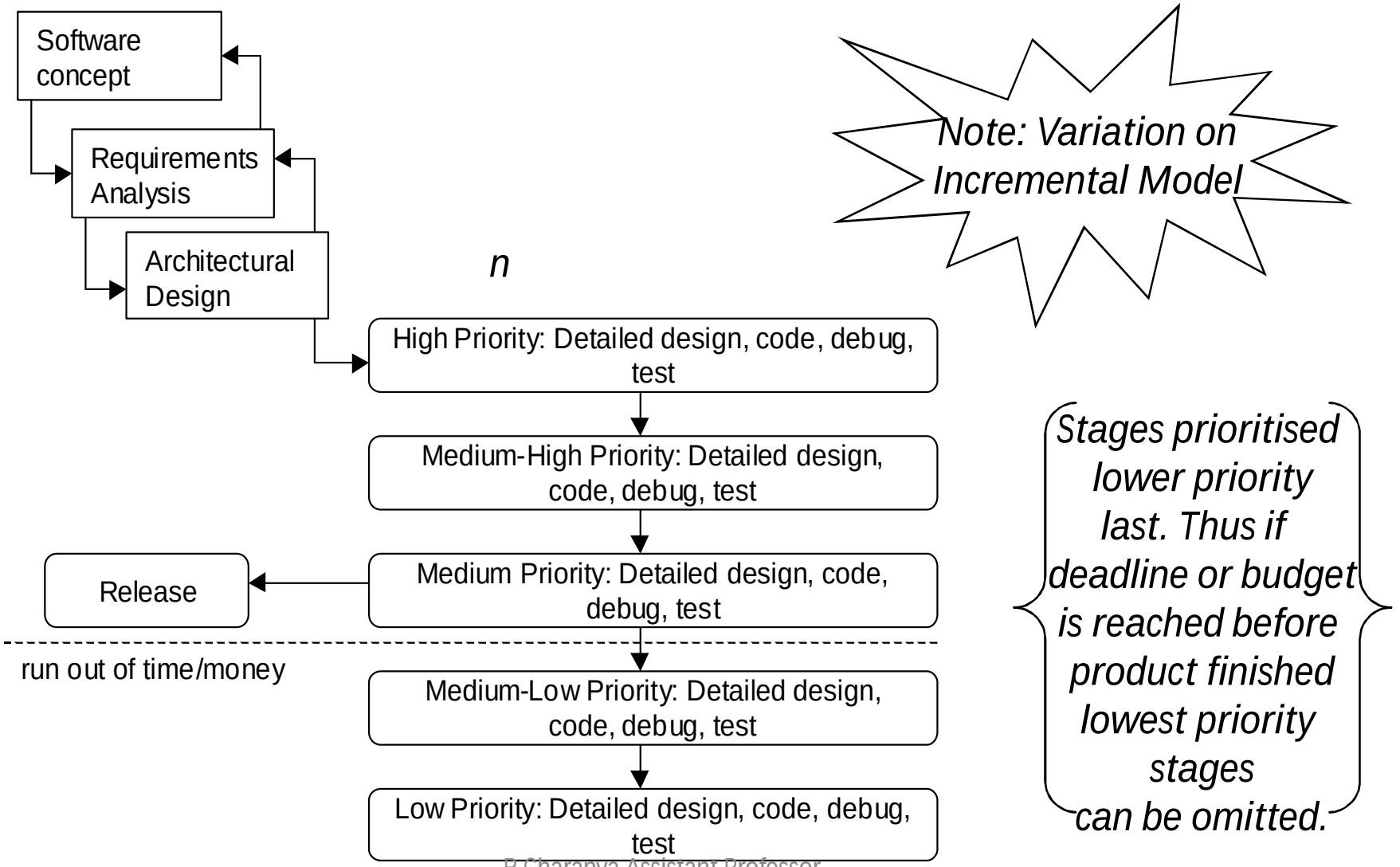


# Incremental (staged) Delivery



# Design-to-Schedule



# Advantages

- requirements gathered in initial stages
- overall architectural design is determined
- requirements met in successive stages of the project
- users get part of the functionality delivered at an early stage (As in evolutionary prototyping)

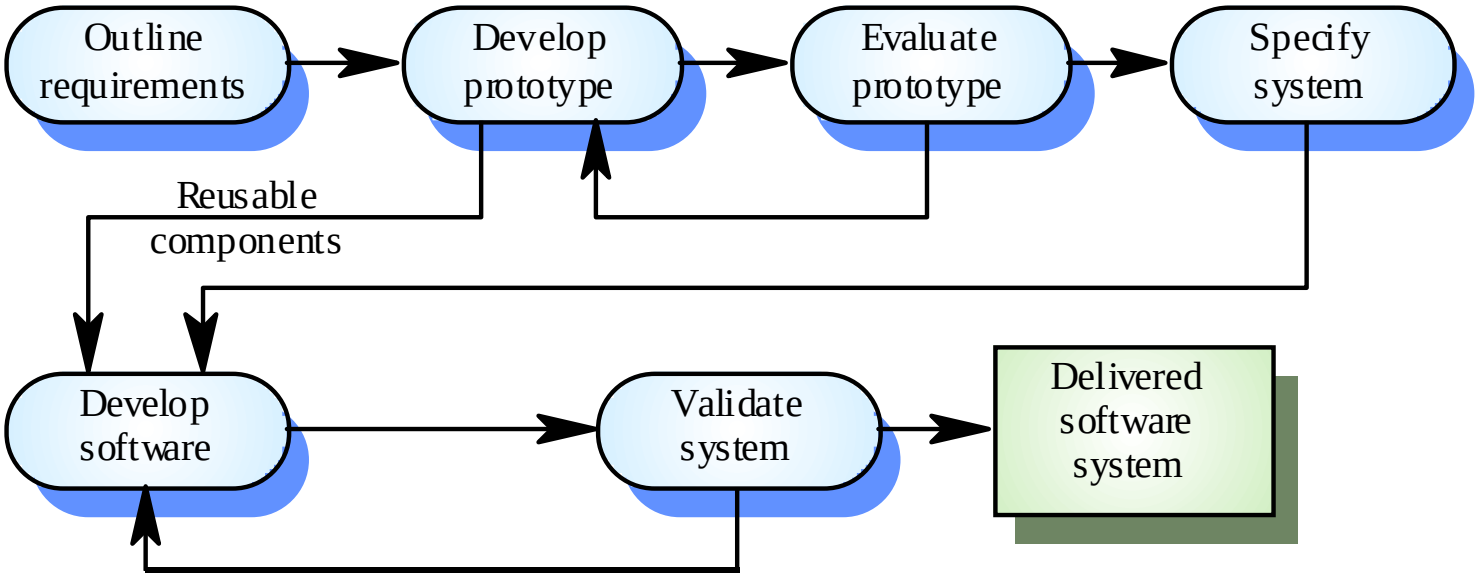
# Disadvantage

- Needs careful planning - stages have interdependencies
- If not planned well - extra effort in interfacing stages
- Users may tire of constant changes
- funding may be difficult to obtain for a succession of changes

# Throw-away prototyping

- Used to reduce requirements risk
- The prototype is developed from an initial specification, delivered for experiment then discarded
- The throw-away prototype should NOT be considered as a final system
  - Some system characteristics may have been left out.
  - There is no specification for long-term maintenance.
  - The system will be poorly structured and difficult to maintain.

# Throw-away prototyping



# Prototype delivery

- Developers may be pressurised to deliver a throw-away prototype as a final system
- This is not recommended
  - It may be impossible to tune the prototype to meet non-functional requirements
  - The prototype is inevitably undocumented
  - The system structure will be degraded through changes made during development
  - Normal organisational quality standards may not have been applied

# Rapid prototyping techniques

- Various techniques may be used for rapid development
  - Dynamic high-level language development
  - Database programming
  - Component and application assembly
- These are not exclusive techniques - they are often used together
- Visual programming is an inherent part of most prototype development systems

# Dynamic high-level languages

- Languages which include powerful data management facilities
- Need a large run-time support system. Not normally used for large system development
- Some languages offer excellent UI development facilities
- Some languages have an integrated support environment whose facilities may be used in the prototype

# Prototyping languages

| Language | Type | Application domain |
|---|---|---|
| Smalltalk | Object-oriented | Interactive systems |
| Java | Object-oriented | Interactive systems |
| Prolog | Logic | Symbolic processing |
| Lisp | List-based | Symbolic processing |

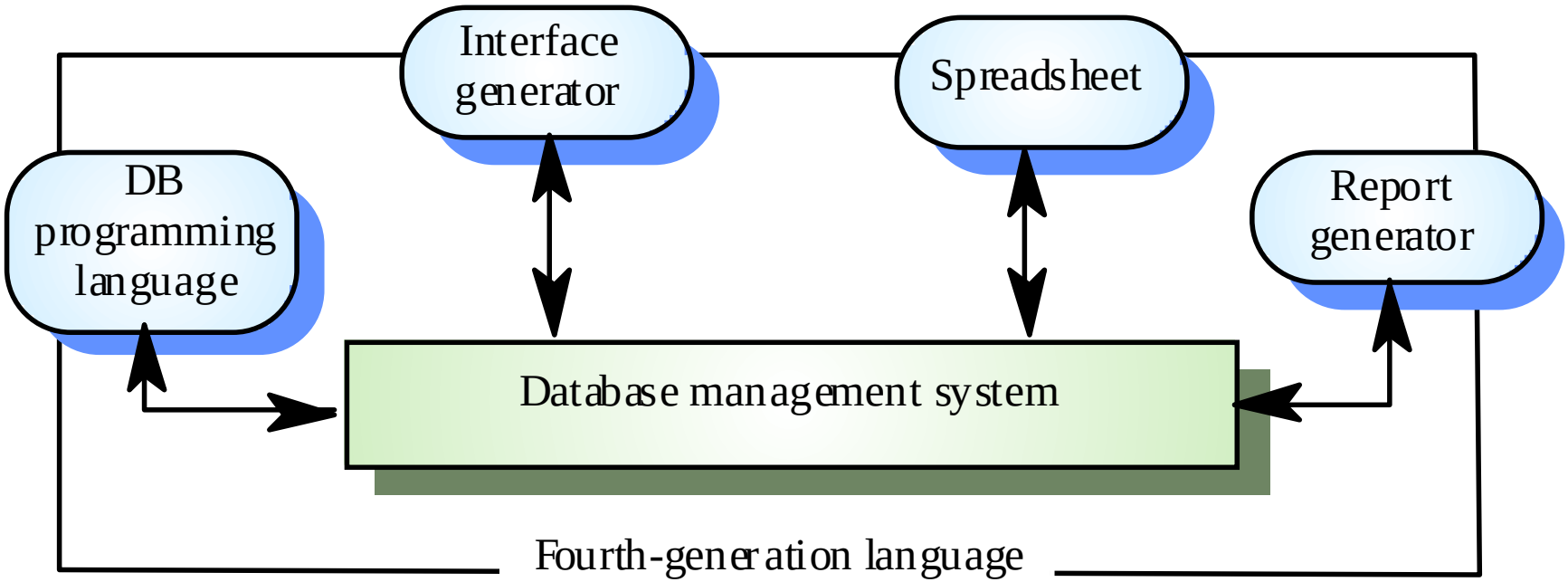
# Choice of prototyping language

- What is the application domain of the problem?
- What user interaction is required?
- What support environment comes with the language?
- Different parts of the system may be programmed in different languages. However, there may be problems with language communications

# Database programming languages

- Domain specific languages for business systems based around a database management system
- Normally include a database query language, a screen generator, a report generator and a spreadsheet.
- May be integrated with a CASE toolset
- The language + environment is sometimes known as a fourth-generation language (4GL)
- Cost-effective for small to medium sized

# Database programming



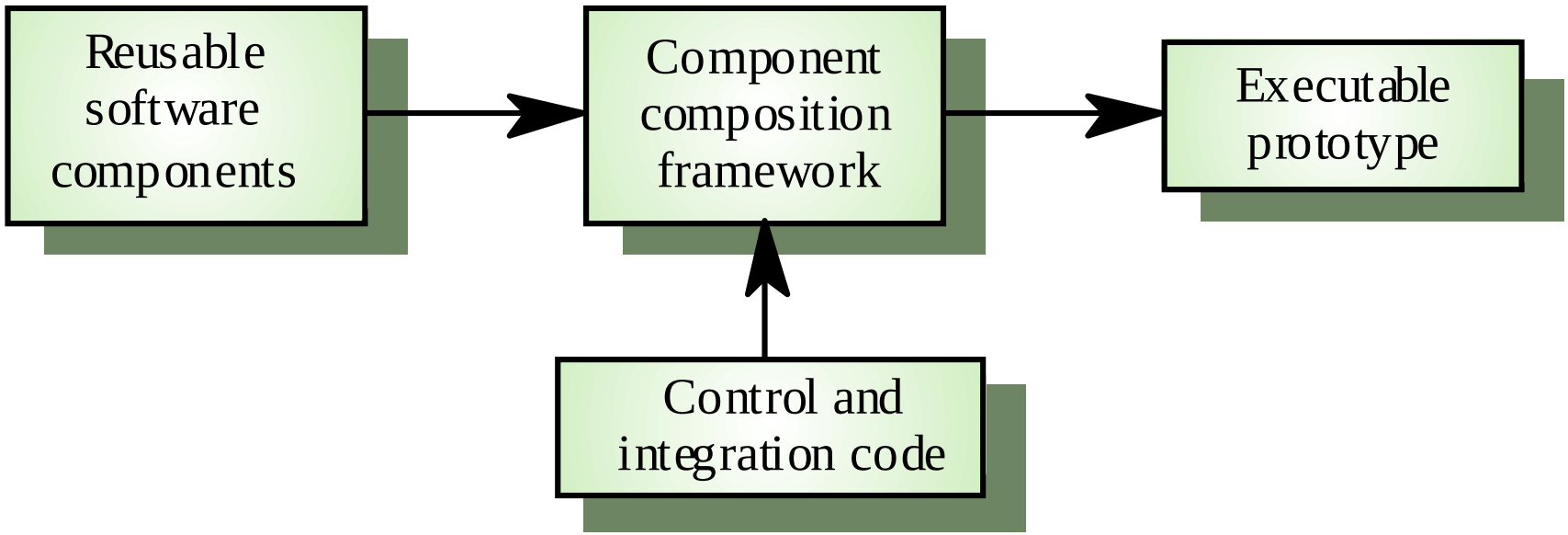
# Component and application assembly

- Prototypes can be created quickly from a set of reusable components plus some mechanism to ‘glue’ these component together
- The composition mechanism must include control facilities and a mechanism for component communication
- The system specification must take into account the availability and functionality of existing components

# Prototyping with reuse

- Application level development
  - Entire application systems are integrated with the prototype so that their functionality can be shared
  - For example, if text preparation is required, a standard word processor can be used
- Component level development
  - Individual components are integrated within a standard framework to implement the system

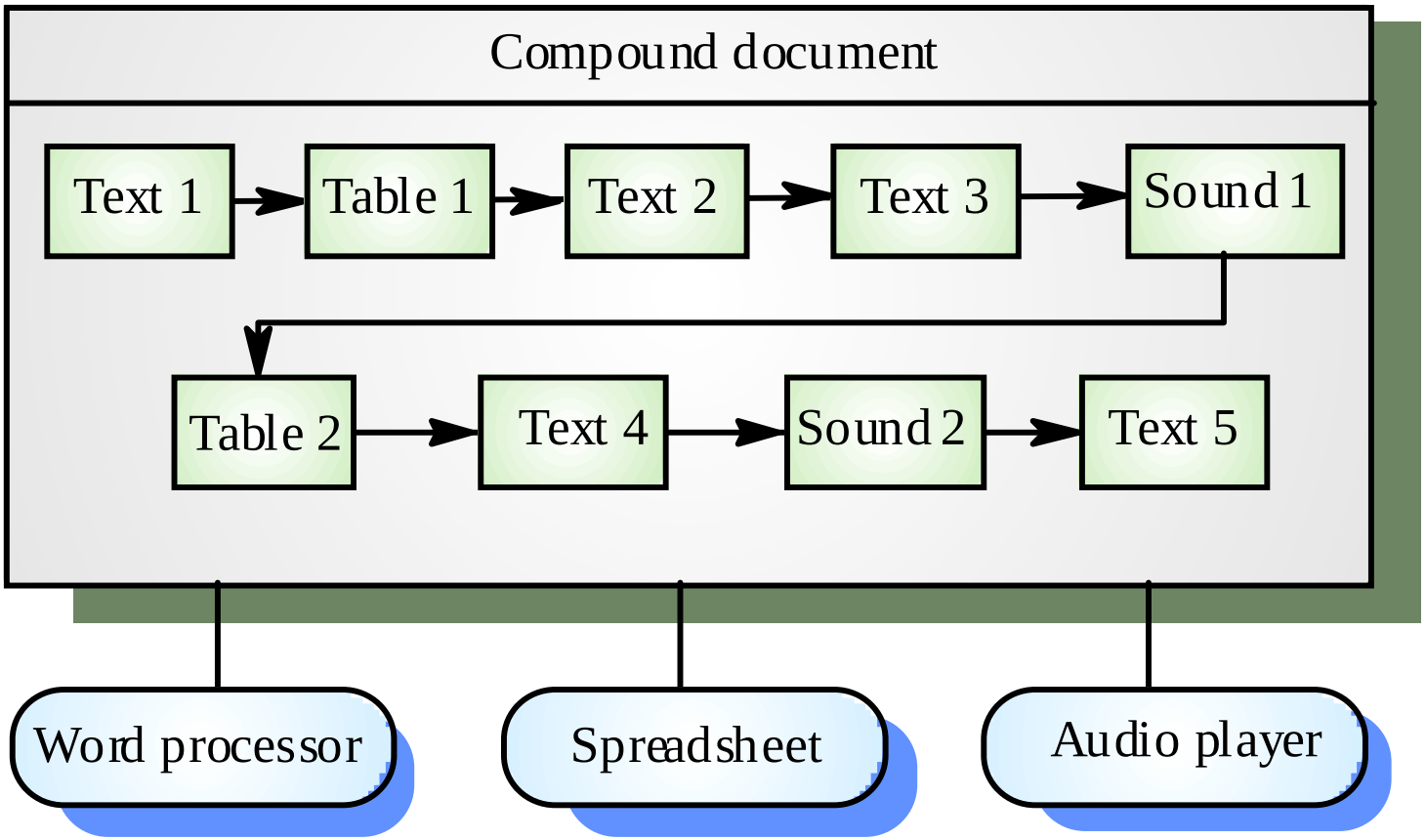
# Reusable component composition



# Compound documents

- For some applications, a prototype can be created by developing a compound document
- This is a document with active elements (such as a spreadsheet) that allow user computations
- Each active element has an associated application which is invoked when that element is selected
- The document itself is the integrator for the different applications

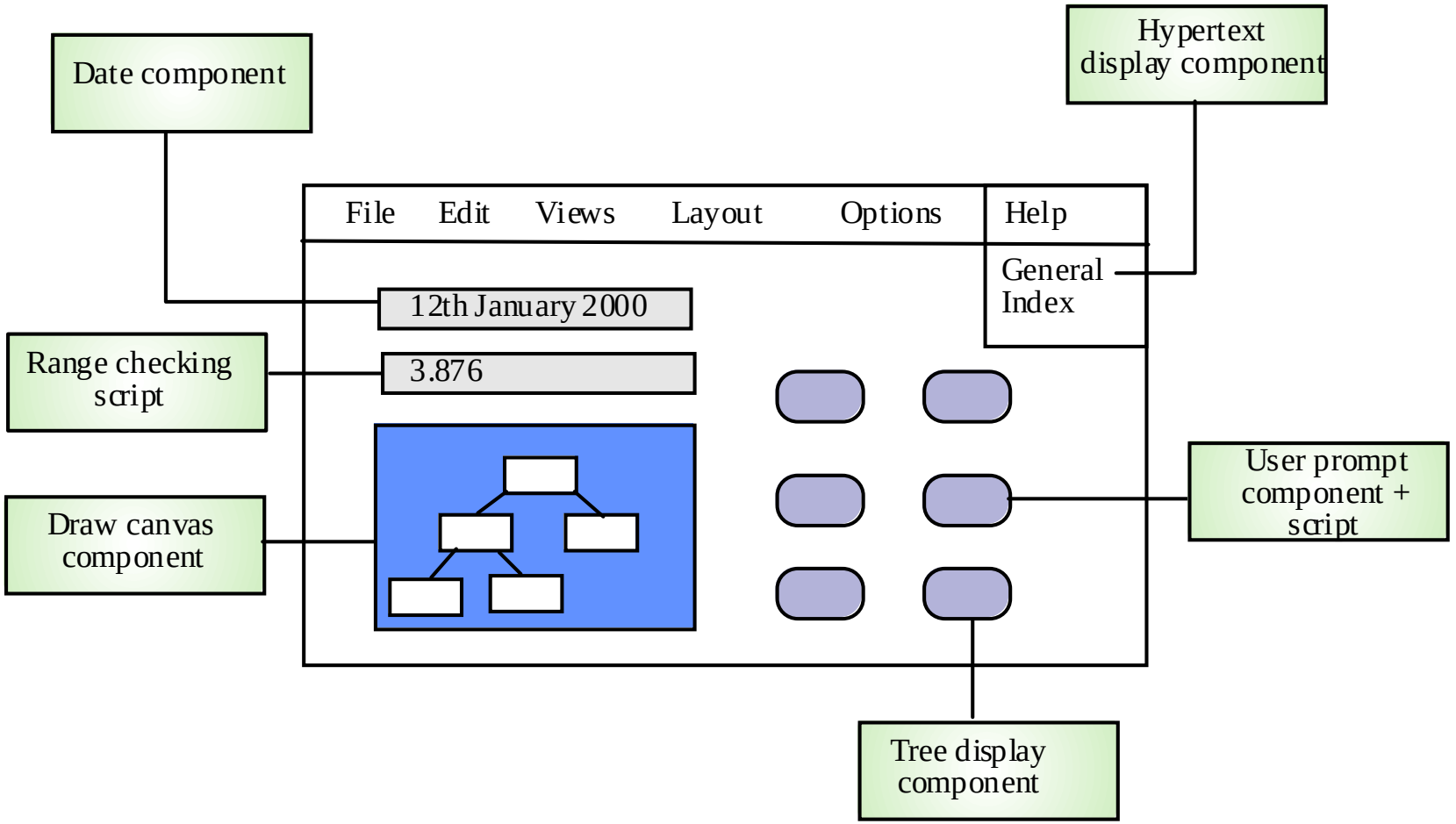
# Application linking in compound documents



# Visual programming

- Scripting languages such as Visual Basic support visual programming where the prototype is developed by creating a user interface from standard items and associating components with these items
- A large library of components exists to support this type of development
- These may be tailored to suit the specific application requirements

# Visual programming with reuse



# Problems with visual development

- Difficult to coordinate team-based development
- No explicit system architecture
- Complex dependencies between parts of the program can cause maintainability problems

# User interface prototyping

- It is impossible to pre-specify the look and feel of a user interface in an effective way. prototyping is essential
- UI development consumes an increasing part of overall system development costs
- User interface generators may be used to ‘draw’ the interface and simulate its functionality with components associated with interface entities
- Web interfaces may be prototyped using a web site editor

# Key points

- A prototype can be used to give end-users a concrete impression of the system's capabilities
- Prototyping is becoming increasingly used for system development where rapid development is essential
- Throw-away prototyping is used to understand the system requirements
- In evolutionary prototyping, the system is developed by evolving an initial version to the

# Key points

- Rapid development of prototypes is essential. This may require leaving out functionality or relaxing non-functional constraints
- Prototyping  techniques include the use of very high-level languages, database programming and prototype construction from reusable components
- Prototyping is essential for parts of the system such as the user interface which cannot be effectively pre-specified. Users must be involved in prototype evaluation