Software Prototyping

- Animating and demonstrating system requirements
Objectives

- To describe the use of prototypes in requirements validation
- To discuss evolutionary and throw-away prototyping
- To introduce rapid prototyping techniques
- To explain the need for user interface prototyping
Topics covered

- Prototyping in the software process
- Prototyping techniques
- User interface prototyping
Uses of system prototypes

- The principal use is to help customers and developers understand the requirements for the system
- The prototype may be used for user training before a final system is delivered
- The prototype may be used for back-to-back testing
Prototyping benefits

- Misunderstandings between software users and developers are exposed
- Missing services may be detected
- 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
Prototyping process

Establish prototype objectives

Prototype plan

Define prototype functionality

Outline definition

Develop prototype

Executable prototype

Evaluate prototype

Evaluation report
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

Outline Requirements → Evolutionary Prototyping → Delivered System

Outline Requirements → Throw-away Prototyping → Executable Prototype + System Specification
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 which allow rapid system iterations
- Verification is impossible as there is no specification. Validation means demonstrating the adequacy of the system
Evolutionary prototyping

Develop abstract specification

Build prototype system

Use prototype system

Deliver system

System adequate?

YES

N
Evol. prototyping problems

- Existing management processes assume a waterfall model of development
- Continual change tends to corrupt system structure so long-term maintenance is expensive
- Specialist skills are required which may not be available in all development teams
- Organisations must accept that the lifetime of systems developed this way will inevitably be short
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

Outline requirements

Develop prototype

Evaluate prototype

Specify system

Reusable components

Develop software

Validate system

Delivered software system

Develop software
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.
- 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

1. Define system deliverables
2. Design system architecture
3. Specify system increment
4. Build system increment
5. Validate system increment
6. Integrate increment
7. Deliver final system
8. Validate system

System complete? YES/NO
Prototyping techniques

- Executable specification languages
- Very high-level languages
- Application generators and 4GLs
- Composition of reusable components
Executable specification languages

- The system is specified in a formal language
- This specification is processed and an executable system is automatically generated
- At the end of the process, the specification may serve as a basis for a re-implementation of the system
Problems with this approach

- Graphical user interfaces cannot be prototyped
- Formal specification development is not a rapid process
- The executable system is usually slow and inefficient
- Executable specifications only allow functional requirements to be prototyped
Very 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

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Smalltalk

- Very powerful system for prototyping interactive systems
- Object-oriented language so systems are resilient to change
- The Smalltalk environment objects are available to the prototype developer
- The system includes support software such as graphical user interface generation tools
Fourth-generation 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
- Cost-effective for small to medium sized business systems
4GLs

- DB query language
- Screen Generator
- Spreadsheet
- Report generator

Fourth-generation language
Prototyping with reuse

- The system is prototyped by ‘gluing’ together existing components
- Likely to become more widely used as libraries of objects become available
- Needs a composition language such as a Unix shell language
- Visual Basic is largely based on this approach
Reusable component composition

Reusable component repository → Component catalogue → System Specification → Component composition system → Executable prototype
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.
- Prototyping may use very high-level languages such as Smalltalk or Lisp.
- User interface generators may be used to ‘draw’ the interface and simulate its functionality.
User interface management system
Key points

- A prototype can be used to give end-users a concrete impression of the system’s capabilities
- Prototyping may be evolutionary prototyping or throw-away prototyping
- Rapid development is essential for prototype systems
- Prototype structures become corrupted by constant change. Hence, long-term evolution is difficult
Key points

- In a throw-away prototype start with the least well-understood parts; in an evolutionary prototype, start with the best understood parts.
- Prototyping methods include the use of executable specification languages, very high-level languages, fourth-generation languages 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.