Lecture 10

OPERATION, MAINTENANCE AND EVOLUTION

PB007 Software Engineering I
Faculty of Informatics, Masaryk University

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Topics covered

- Evolution processes
  - Change processes for software systems
- Software maintenance
  - Making changes to operational software systems
- Refactoring and reengineering
- Legacy system management
  - Making decisions about software change

Evolution Processes

Lecture 10/Part 1

Software change

- Software **change is inevitable**
  - New requirements emerge when the software is used;
  - The business environment changes;
  - Errors must be repaired;
  - New computers and equipment is added to the system;
  - The performance or reliability of the system may have to be improved.
- For custom systems, the **costs** of software maintenance usually **exceed the software development costs**.
- A key problem for all organizations is implementing and **managing change** to their existing software systems.

A spiral model of development & evolution

Specification

Implemention

Start

etc.

Release 1

Operation

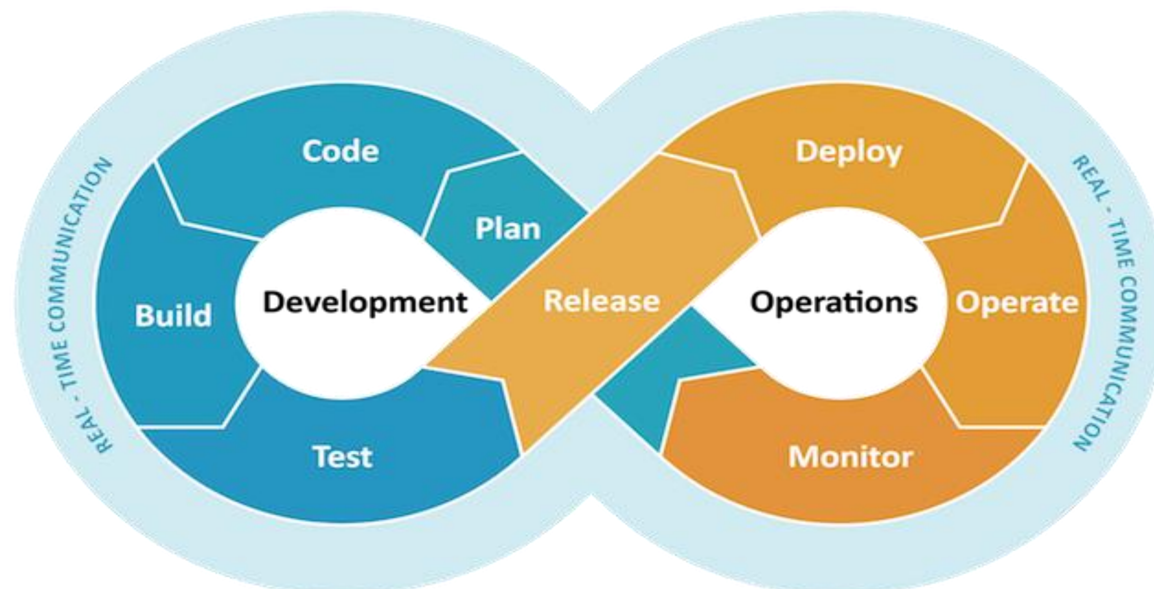
Validation

Release 2

Release 3

DevOps

- A set of practices that combines software development (Dev) and operations (Ops) which aims to shorten the development life cycle and provide continuous delivery with high software quality
- A culture that promotes collaboration between Development and Operations team that makes the team more efficient



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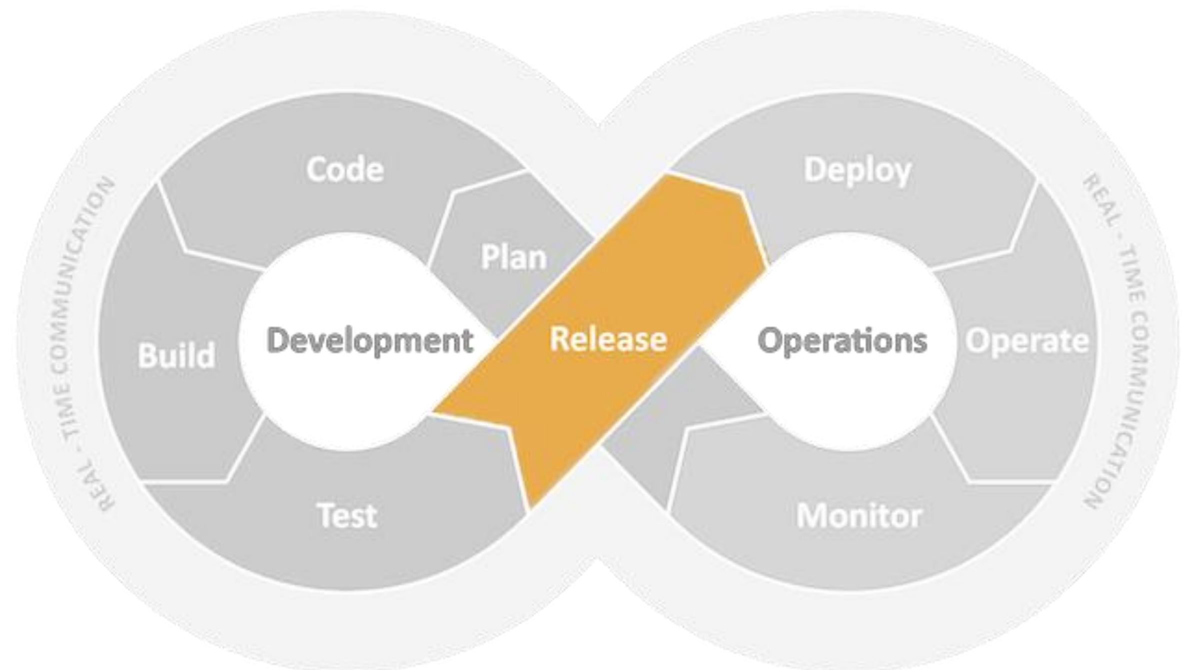
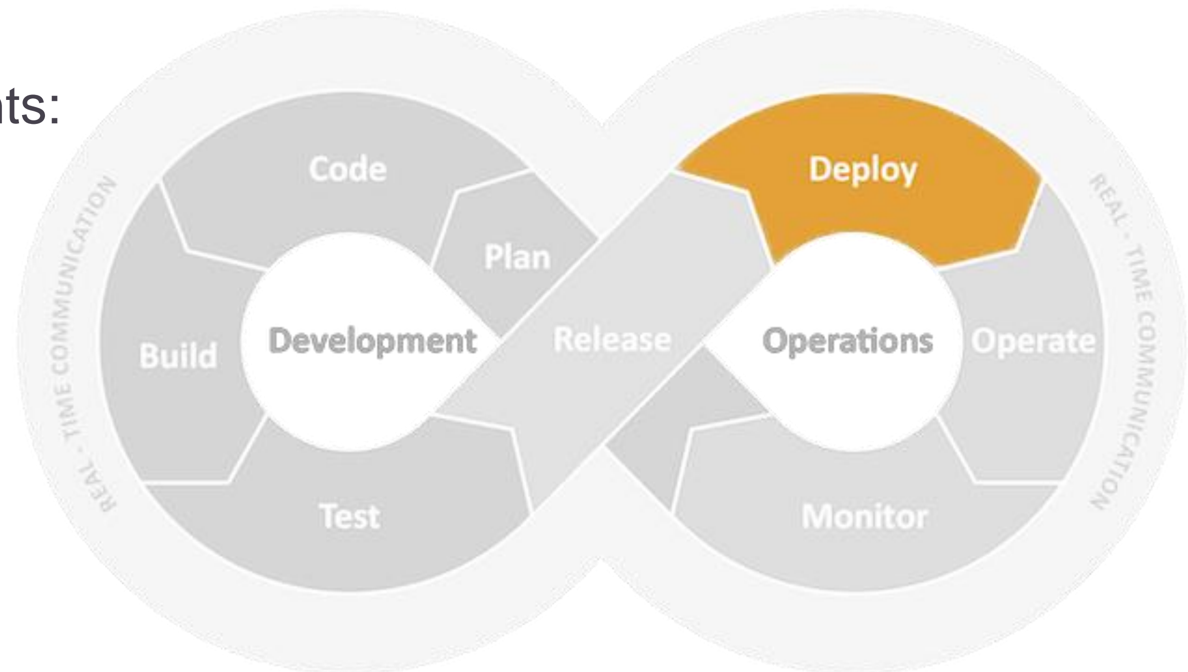
Release

- A distribution of a version of software
- At the end of each iteration in agile methodologies
- Software has to be planned, implemented, tested and then delivered to customer or released into production



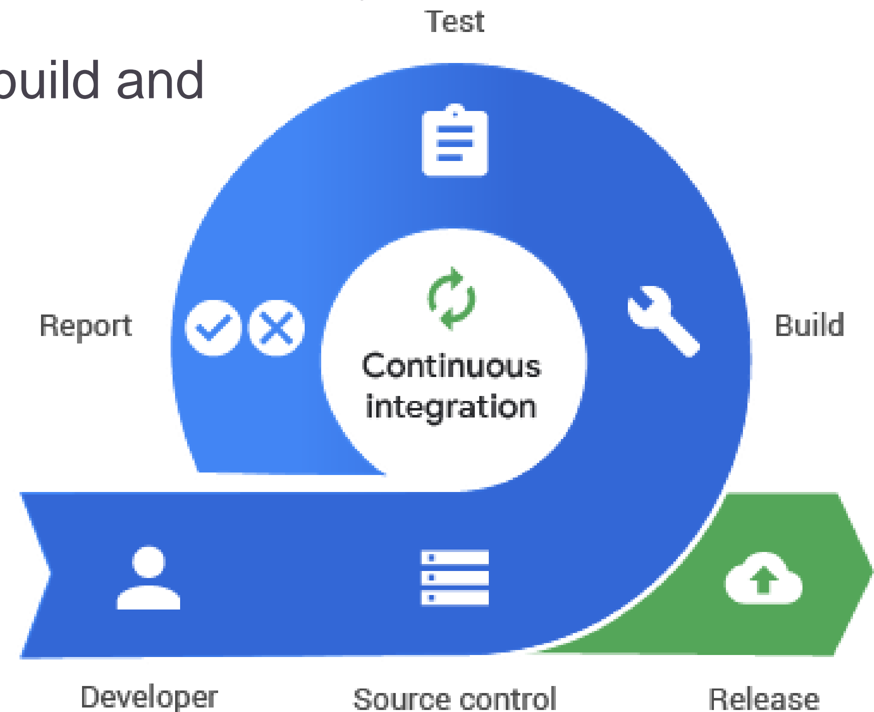
Deployment

- The process required for preparing a software application to run and operate in a specific environment
- Deployment plan to ensure changes are made the same way every time
- Various environments:
  - Local
  - Development
  - Staging
  - Production



Continuous Integration

- A development practice that requires developers to regularly integrate code into a shared repository
- The process of automating the build and testing of code every time a team member commits changes to version control
- Process can help detect errors quickly and locate them easily



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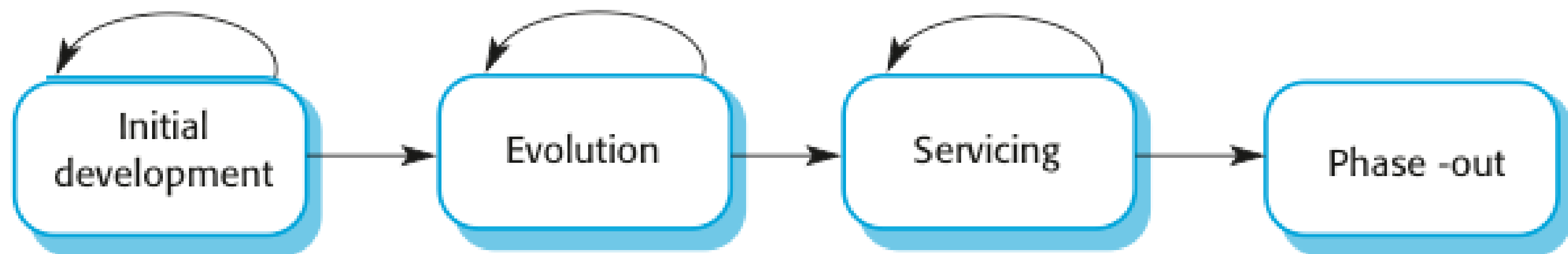
Evolution and servicing

- ✧ Evolution
  - New functionality added, faults repaired.
- ✧ Servicing
  - Faults repaired, no new functionality added.
- ✧ Phase-out
  - The software still in use but no further changes are made to it.

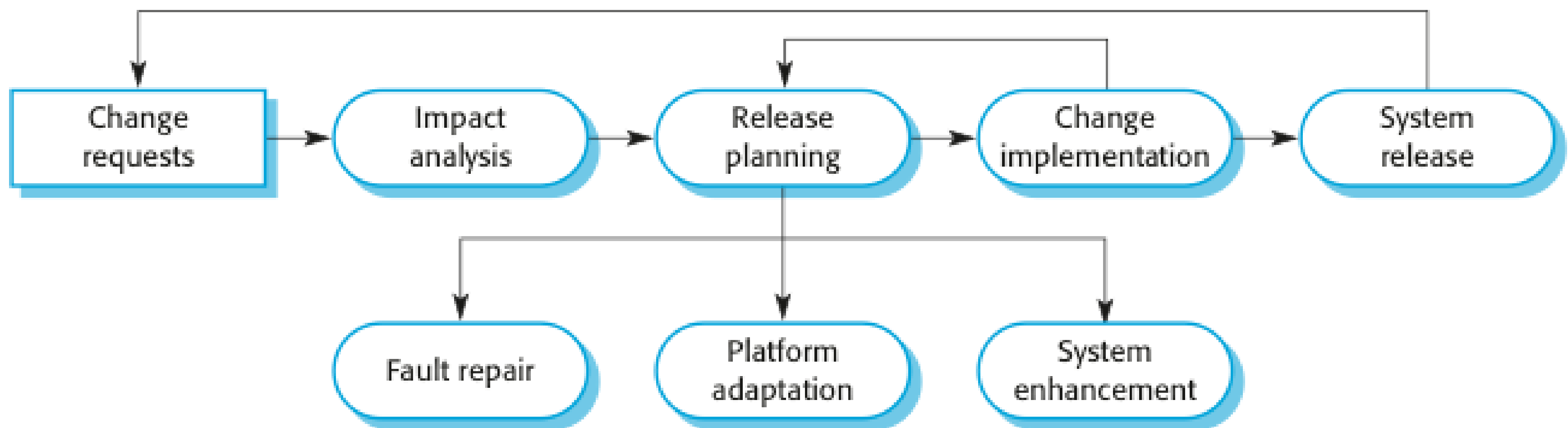


Evolution processes

✧ Proposals for **change** are the **driver** for SW evolution.

- Should be linked with components that are affected by the change, thus allowing the cost and impact of the change to be estimated.

✧ Change identification and evolution continues throughout the system lifetime.



More on change implementation

- **Iteration of the development process** where the revisions to the system are designed, implemented and tested.
  - May be done by a **different team**, not the original developers.
  - Involves **program understanding**, especially if no original developers are involved.
  - During the program understanding phase, one has to understand **how the proposed change might affect the program**.
- **Urgent changes** may have to be implemented without going through all stages of the evolution process.
- **Technical debt** may be created and must be managed.

Technical debt

✧ Technical Debt Management

- Introduced by Ward Cunningham
- Analogy of quality degradation with financial debt
  – if not paid off, interests increase. One can get into trouble.

✧ Sometimes it is wise to “borrow money”

- When one expects to have more money in the future (start-up company)
- When one needs to act fast not to miss a market opportunity
- When one expects money devaluation (e.g. developers will become more experienced, it will be easier to understand user needs)

✧ Sometimes not

Agile methods and evolution

- Agile methods are based on incremental development so the transition from development to evolution is seamless.
  - Evolution is simply a continuation of the development process based on frequent system releases.
- **Automated regression testing** is particularly valuable when changes are made to a system.
- **Handover problems**
  - What if the development team is agile and the evolution team is not?
  - What if the evolution team is agile and the development team is not?

Software Maintenance

Lecture 10/Part 2

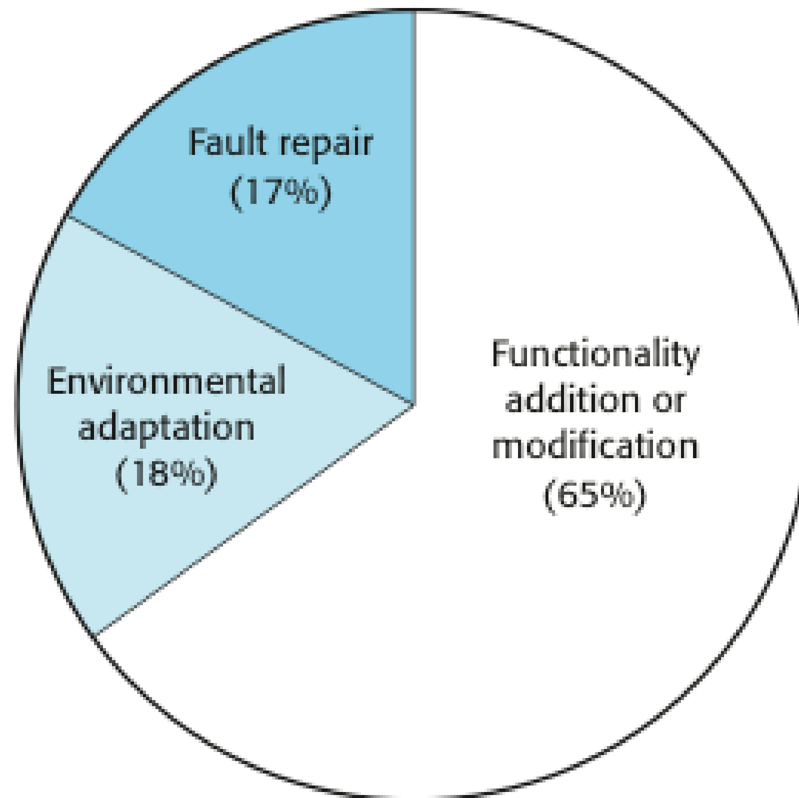
Software maintenance

- Modifying a program after it has been put into use.
- The term is mostly used for changing **custom software**. Generic software products are said to evolve to create new versions.
- Maintenance **does not** normally **involve major changes** to the system’s architecture.
- Changes are implemented by modifying existing components and adding new components to the system.

Types of maintenance

- **Corrective:** Maintenance to repair software faults
  - Changing a system to correct deficiencies in the way meets its requirements.
- **Adaptive:** Maintenance to adapt software to a different operating environment
  - Changing a system so that it operates in a different environment (computer, OS, etc.) from its initial implementation.
- **Evolutionary:** Maintenance to add to or modify the system's functionality
  - Modifying the system to satisfy new requirements.

Maintenance effort distribution



Maintenance prediction and planning

What parts of the system are most likely to be affected by change requests?

What parts of the system will be the most expensive to maintain?

Predicting maintainability

Predicting system changes

Predicting maintenance costs

What will be the lifetime maintenance costs of this system?

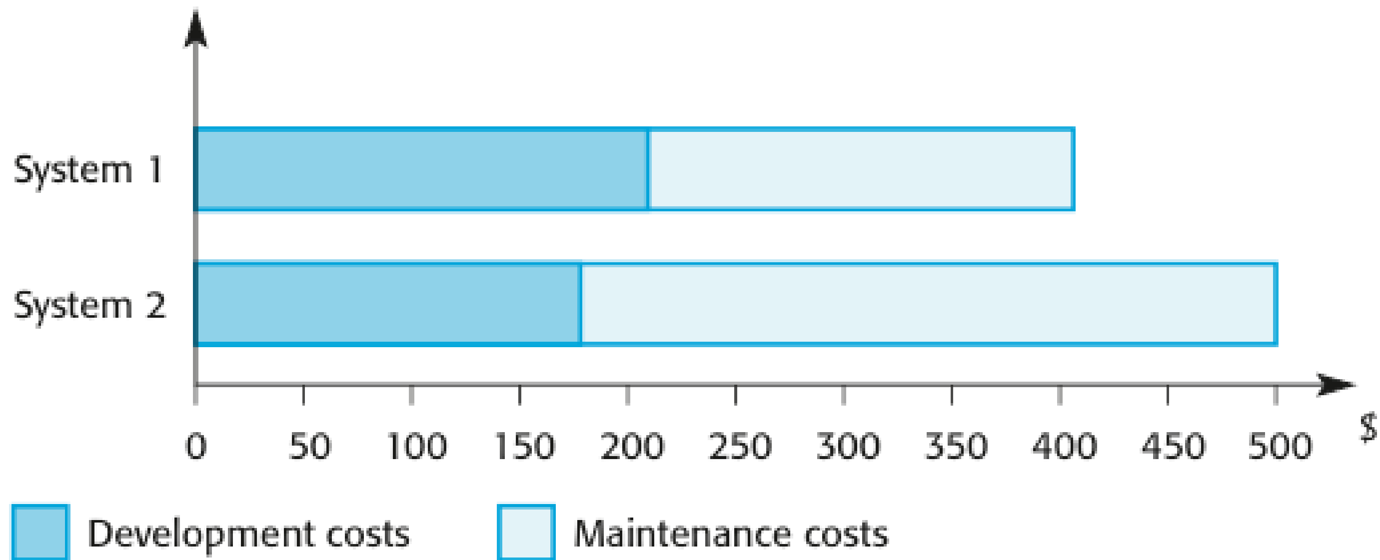
How many change requests can be expected?

What will be the costs of maintaining this system over the next year?

1. Predicting maintenance costs

- ✧ Usually greater than development costs (1* to 20* depending on the application).
  - Experience with custom information systems shows that around 20% of development costs needs to be allocated to maintenance every year (within the first five years).
- ✧ Affected by both technical and non-technical factors.
- ✧ Increases as software is maintained. Maintenance **corrupts the software structure** so makes further maintenance more difficult.
- ✧ **Ageing software** can have high support costs (e.g. old languages, compilers etc.).

Development and maintenance costs



Maintenance cost factors

- Team stability
  - Maintenance costs are reduced if the same staff are involved with them for some time.
- Contractual responsibility
  - The developers of a system may have no contractual responsibility for maintenance so there is no incentive to design for future change.
- Staff skills
  - Maintenance staff are often inexperienced and have limited domain knowledge.
- Program age and structure
  - As programs age, their structure is degraded and they become harder to understand and change.

2. Predicting system changes

- Predicting the number of changes requires an **understanding of the relationships** between the system and its environment.
- Tightly coupled systems require changes **whenever the environment is changed**.
- Factors influencing this relationship are
  - Number and complexity of system **interfaces**;
  - Number of inherently **volatile system requirements**;
  - The **business processes** where the system is used.

Complexity metrics

- Predictions of maintainability can be made by assessing the complexity of system components.
- Studies have shown that most maintenance effort is spent on a **relatively small number** of system components.
- Complexity depends on
  - Complexity of control structures;
  - Complexity of data structures;
  - Object, method (procedure) and module size.

3. Predicting maintainability

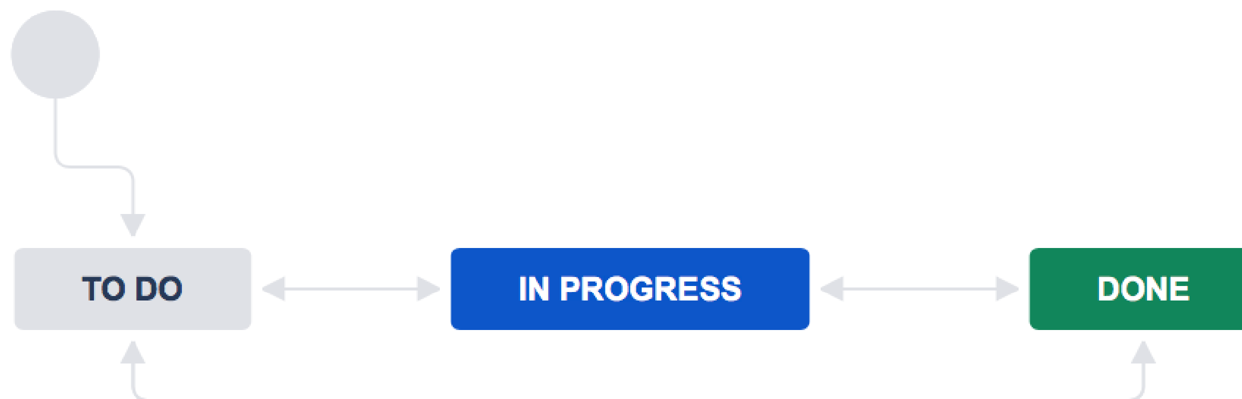
- **Planning**
  - What parts of the system will be the most expensive to maintain?

- **Process metrics** may be used to assess maintainability
  - Number of requests for corrective maintenance;
  - Average time required for impact analysis;
  - Average time taken to implement a change request;
  - Number of outstanding change requests.

- If any or all of these **is increasing**, this may indicate a **decline in maintainability**.

Change/Issue tracking

- Process of recording and following the progress of a software issue, change request until the problem is resolved
- Mostly used in a customer support to report customer issues
- Issues are transformed into tickets that contain report of the problem and its status
- Also used as a software project tracking and management



Issue tracking board

TO DO 5

- Engage Jupiter Express for outer solar system travel — SPACE TRAVEL PARTNERS — 5 — TIS-25
- Create 90 day plans for all departments in the Mars Office — LOCAL MARS OFFICE — 9 — TIS-12
- Engage Saturn's Rings Resort as a preferred provider — SPACE TRAVEL PARTNERS — 3 — TIS-17
- Enable Speedy SpaceCraft as the preferred

IN PROGRESS 5

- Requesting available flights is now taking > 5 seconds — SEESPACEEZ PLUS — 3 — ~~TIS-8~~
- Engage Saturn Shuttle Lines for group tours — SPACE TRAVEL PARTNERS — 4 — TIS-15
- Establish a catering vendor to provide meal service — LOCAL MARS OFFICE — 4 — TIS-15
- Engage Saturn Shuttle Lines for group tours

CODE REVIEW 2

- Register with the Mars Ministry of Revenue — LOCAL MARS OFFICE — 3 — TIS-11
- Draft network plan for Mars Office — LOCAL MARS OFFICE — 3 — TIS-15

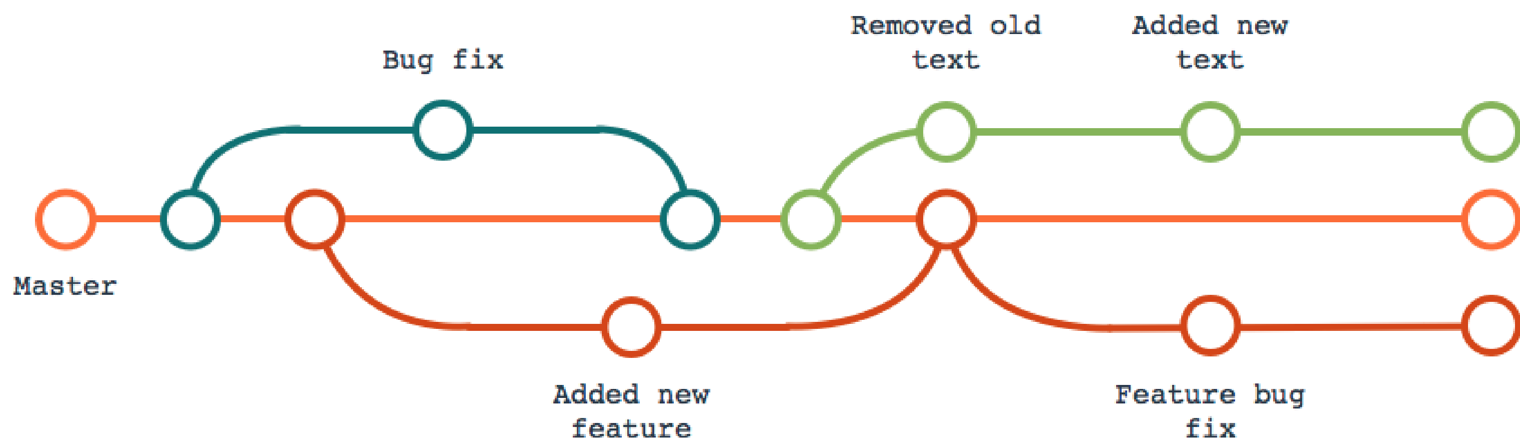
DONE 8

- Homepage footer uses an inline style - should use a class — LARGE TEAM SUPPORT — TIS-68
- Engage JetShuttle SpaceWays for travel — SPACE TRAVEL PARTNERS — 5 — TIS-23
- Engage Saturn Shuttle Lines for group tours — SPACE TRAVEL PARTNERS — TIS-15
- Establish a catering vendor to provide meal service — LOCAL MARS OFFICE

https://brainhub.eu/blog/wp-content/uploads/2018/08/best-issue-tracking-systems-jira.png

Version control

- A system that records changes to files over time so that specific versions can be recalled later
- Allows comparing changes and reverting files back to a previous state
- Code is organized in a tree structure – developers can work on some parts of that tree and later can merge their changes together



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Refactoring and Reengineering

Lecture 10/Part 3

System reengineering

- Re-structuring or re-writing part or all of a legacy system **without changing its functionality**.
- Applicable where some but not all sub-systems of a larger system require frequent maintenance.
- Reengineering involves adding effort to **make them easier to maintain**. The system may be re-structured and re-documented.

- How does reengineering relate to refactoring?
- How does reengineering relate to technical debt?

Advantages of reengineering

- ✧ Reduced risk
  - There is a high risk in new software development. There may be development problems, staffing problems and specification problems.
- ✧ Reduced cost
  - The cost of reengineering is often significantly less than the costs of developing new software.

Reengineering activities

- ✧ Source code translation
  - Convert code to a new language.
- ✧ Reverse engineering
  - Analyse the program to understand it;
- ✧ Program structure improvement
  - Restructure automatically for understandability;
- ✧ Program modularisation
  - Reorganise the program structure;
- ✧ Data reengineering
  - Clean-up and restructure system data.

The reengineering process example

Original program

Source code translation

Reverse engineering

Program structure improvement

Program documentation

Program modularization

Restructured program

Re-engineered program

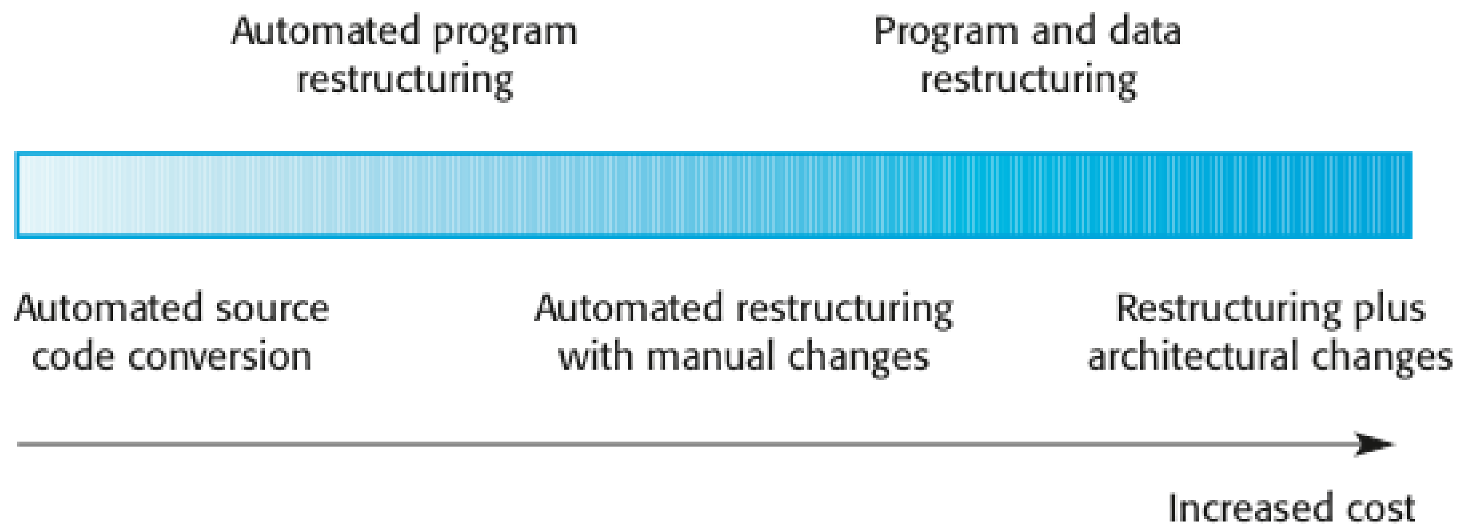
Original data

Data re-engineering

Re-engineered data

Reengineering cost factors

- ✧ The quality of the software to be reengineered.
- ✧ The tool support available for reengineering.
- ✧ The extent of the data conversion which is required.
- ✧ The availability of expert staff for reengineering.



Refactoring

- A process of modifying a program to improve its structure, reduce its complexity or make it easier to understand
- It is intended to avoid the structure and code degradation that increases the costs and difficulties of maintaining a system
- Should be done in small steps without changing the program's behaviour

```
1 public boolean max(int a, int b) {
2     if(a > b) {
3         return true;
4     } else if (a == b) {
5         return false;
6     } else {
7         return false;
8     }
9 }
```

```
1 public boolean max(int a, int b) {
2     return a > b;
3 }
```

Preventative maintenance by refactoring

- Refactoring is the process of making improvements to a program to **slow down degradation** through change.
- You can think of refactoring as '**preventative maintenance**' that reduces the problems of future change.
- Refactoring involves modifying a program **to improve its structure**, **reduce its complexity** or make it **easier to understand**.
- When you refactor a program, you **should not add or change functionality** but concentrate on code quality improvement.

Refactoring and reengineering

- **Reengineering** takes place after a system has been maintained for some time and maintenance costs are increasing. You use automated tools to process and reengineer a legacy system to create a new system that is more maintainable.
- **Refactoring** is a continuous process of improvement throughout the development and evolution process. It is intended to avoid the structure and code degradation that increases the costs and difficulties of maintaining a system.

Examples of 'Bad Smells' in program code

- Duplicate code
  - Can be implemented as a single method or function that is called as required.
- S.O.L.I.D. violated
  - God classes, long methods, which should be split.
- Different abstraction levels
  - Not top down - mixed, skipping levels, mixing levels in one method.
- Circular dependencies
- Long parameter list

Key points

- There are 3 types of software maintenance, namely **bug fixing**, modifying software to **work in a new environment**, and implementing **new or changed requirements**.
- **Software reengineering** is concerned with re-structuring and re-documenting software to make it easier to understand and change.
- **Refactoring**, making program changes that preserve functionality, is a form of preventative maintenance.

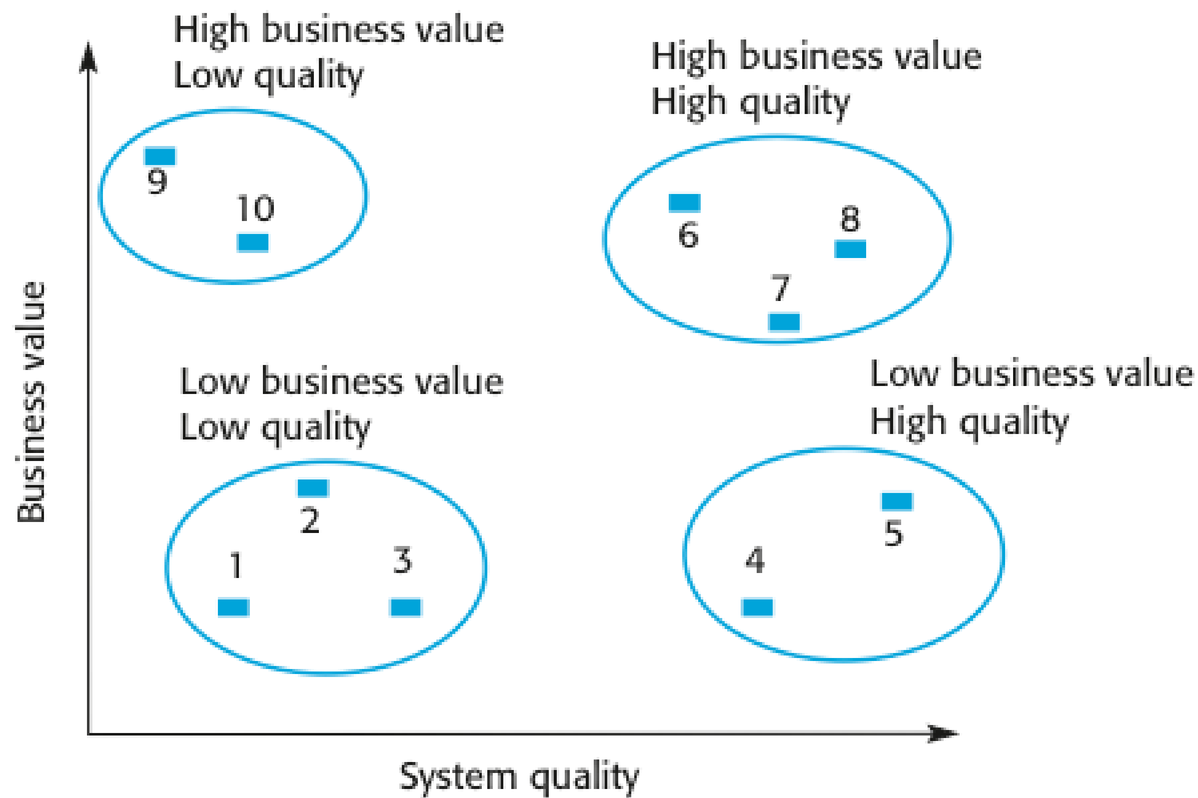
Legacy System Management

Lecture 10/Part 4

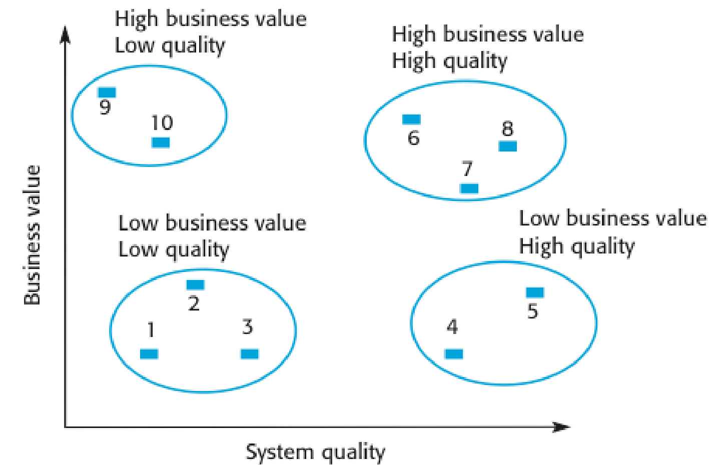
Legacy system management

- Organisations that rely on legacy systems must choose a strategy for evolving these systems
  - **Scrap:** Scrap the system completely and modify business processes so that it is no longer required;
  - **Maintain:** Continue maintaining the system;
  - **Reengineer:** Transform the system by reengineering to improve its maintainability;
  - **Replace:** Replace the system with a new system.
- The strategy chosen should depend on the **system quality** and its **business value**.

An example of a legacy system assessment



Legacy system categories



- ✧ Low quality, low business value
  - These systems should be scrapped.
- ✧ Low quality, high business value
  - These make an important business contribution but are expensive to maintain. Should be reengineered or replaced if a suitable system is available.
- ✧ High quality, low business value
  - Scrap or increase the business value – see on later slides.
- ✧ High quality, high business value
  - Continue in operation using normal system maintenance.

Business value assessment

- Assessment should take different viewpoints into account
  - System end-users;
  - Business customers;
  - Line managers;
  - IT managers;
  - Senior managers.
- Interview different stakeholders and collate results.

System quality assessment

- **Application assessment**
  - What is the quality of the application software system? How expensive it is to maintain?
- **Environment assessment**
  - How effective is the system's environment? How expensive it is to maintain?
- You may collect quantitative data to make an assessment of the quality of the application system
  - The number of system change requests;
  - The number of different user interfaces used by the system;
  - The volume of data used by the system.

Factors used in application assessment

Factor	Questions
Understandability	How difficult is it to understand the source code of the current system? How complex are the control structures that are used? Do variables have meaningful names that reflect their function?
Documentation	What system documentation is available? Is the documentation complete, consistent, and current?
Data	Is there an explicit data model for the system? To what extent is data duplicated across files? Is the data used by the system up to date and consistent?
Performance	Is the performance of the application adequate? Do performance problems have a significant effect on system users?

Factors used in application assessment

Factor	Questions
Programming language	Are modern compilers available for the programming language used to develop the system? Is the programming language still used for new system development?
Configuration management	Are all versions of all parts of the system managed by a configuration management system? Is there an explicit description of the versions of components that are used in the current system?
Test data	Does test data for the system exist? Is there a record of regression tests carried out when new features have been added to the system?
Personnel skills	Are there people available who have the skills to maintain the application? Are there people available who have experience with the system?

Factors used in environment assessment

Factor	Questions
Supplier stability	Is the supplier still in existence? Is the supplier financially stable and likely to continue in existence? Is the supplier replaceable?
Failure rate	Does the hardware have a high rate of reported failures? Does the support software crash and force system restarts?
Age	How old is the hardware and software? The older the hardware and support software, the more obsolete it will be.
Performance	Is the performance of the system adequate? Do performance problems have a significant effect on system users?
Support requirements	What local support is required by the hardware and software? If high, it may be worth considering system replacement.
Maintenance costs	What are the costs of hardware maintenance and support software licenses (annual licensing costs)?
Interoperability	Are there problems interfacing the system to other systems? Can compilers, for example, be used with current versions of the operating system? Is hardware emulation required?

Key points

✧ The business value of a legacy system and the quality of the application should be assessed to help decide if a system should be replaced, transformed or maintained.

✧ The business-value assessment should take different stakeholder viewpoints into account.