Human Centred Systems Design

Part 2: Project Management

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(thanks to Dr Anthony Simons for providing the original slides)

The University Of Sheffield.

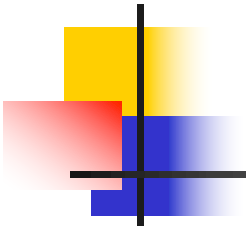
Bibliography

- Software Engineering
  - I Sommerville, Software Engineering, 8th ed., Addison-Wesley, 2006.
  - R S Pressman, Software Engineering: A Practitioner's Approach, 6th ed., McGraw-Hill, 2005.
- Unified Modelling Language
  - S Bennett, S McRobb R Farmer, Object-Oriented Systems Analysis and Design using UML, 3rd ed., McGraw-Hill, 2005.
  - OMG UML portal: http://www.uml.org/

Outline

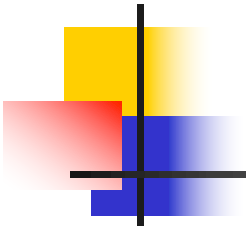
- Managing customers, developers
- Managing development risks
- Systems and software systems
- Requirements engineering process
- Psychological and socio-political issues
- Modelling and coordination

Reading: Sommerville chapters 2, 5, 6, 7, 16, 25;
Pressman chapters 5, 21, 25;
Bennett, et al. chapters 4, 6, 7



Project Management

- Managing the "four Ps"
  - people – customers, developer teams
  - product – software system, context
  - process – lifecycle, analysis and design
  - project – deadlines, deliverables, risks
- Key issues
  - mitigate risks of failure
  - satisfy customer expectations
  - deliver on time and within budget

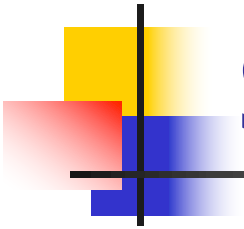


People Management

- Customer and stakeholders
  - customer – commissions the system
    - may be a business manager, company IT director
  - stakeholders – have vested interests
    - business managers – business policies, goals
    - business end-users – usability of the system
    - third-party customers – source of business revenues
- Developer teams
  - senior managers – run the software house
  - technical managers – manage individual projects
  - developers – produce designs, code

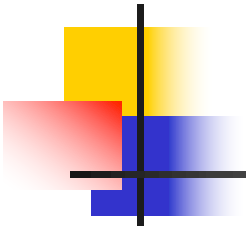
Business Stakeholders

- Definition of "Customer"
  - your client, the person who commissions the system – you must meet his/her objectives
  - but he/she may not be the final end-user – may not understand all the operational issues
- Definition of "Stakeholders"
  - someone with a vested interest in how the system will work
  - different manager, support, end-user, beneficiary roles
  - conflicting interests in how the system works – different preferences, or outright resistance!
  - need to balance interests of all these parties – deal with socio-political aspects, such as balance of power in the workplace
  - need to manage expectations – what is possible, desirable, impossible to deliver



Software Developers

- Required skills
  - technical – design, coding accuracy
  - communication – within team, with customer
  - cohesion – needs good distribution of skills
    - customer interaction, analysis and design skills, coding and testing skills
- Management issues
  - distribute workload fairly (novice/expert issues)
  - coordinate work increments
    - planning, review meetings; feedback, troubleshooting
    - have long/medium/short-term plans and recovery strategy
    - documentation (models, agendas, minutes, plans, charts)



Product Management

- Scope of the project
  - business context, objectives, what is within/outside scope
  - functional requirements vs performance constraints
  - new build vs extension; standalone vs interoperable system; one-off system vs one in a product line
- Problem decomposition
  - divide and conquer: split into modules and subsystems
  - architecture: distribution over different machines, sites, etc
- Quantitative estimates
  - need exact costing and time information, mostly when solid information is unavailable!
  - eg: COCOMO II [Boehm, 2000] – rigorous cost estimation model
  - eg: function point analysis – lightweight cost estimation model

Function Point Analysis

- Basic idea
  - identify the main business functions – main tasks supported by the system, done by the system's end-users
  - score each function on a scale of 1..3 (easy..hard) based on how difficult to implement, and sum the function points
  - pick a constant and multiply the function points by this constant, to yield the total size (time, cost) of the project
- Difficulties
  - picking accurate size, time, cost constants is a black art!
  - novice developers typically under-estimate time and cost of developing a system by up to a factor of 3!

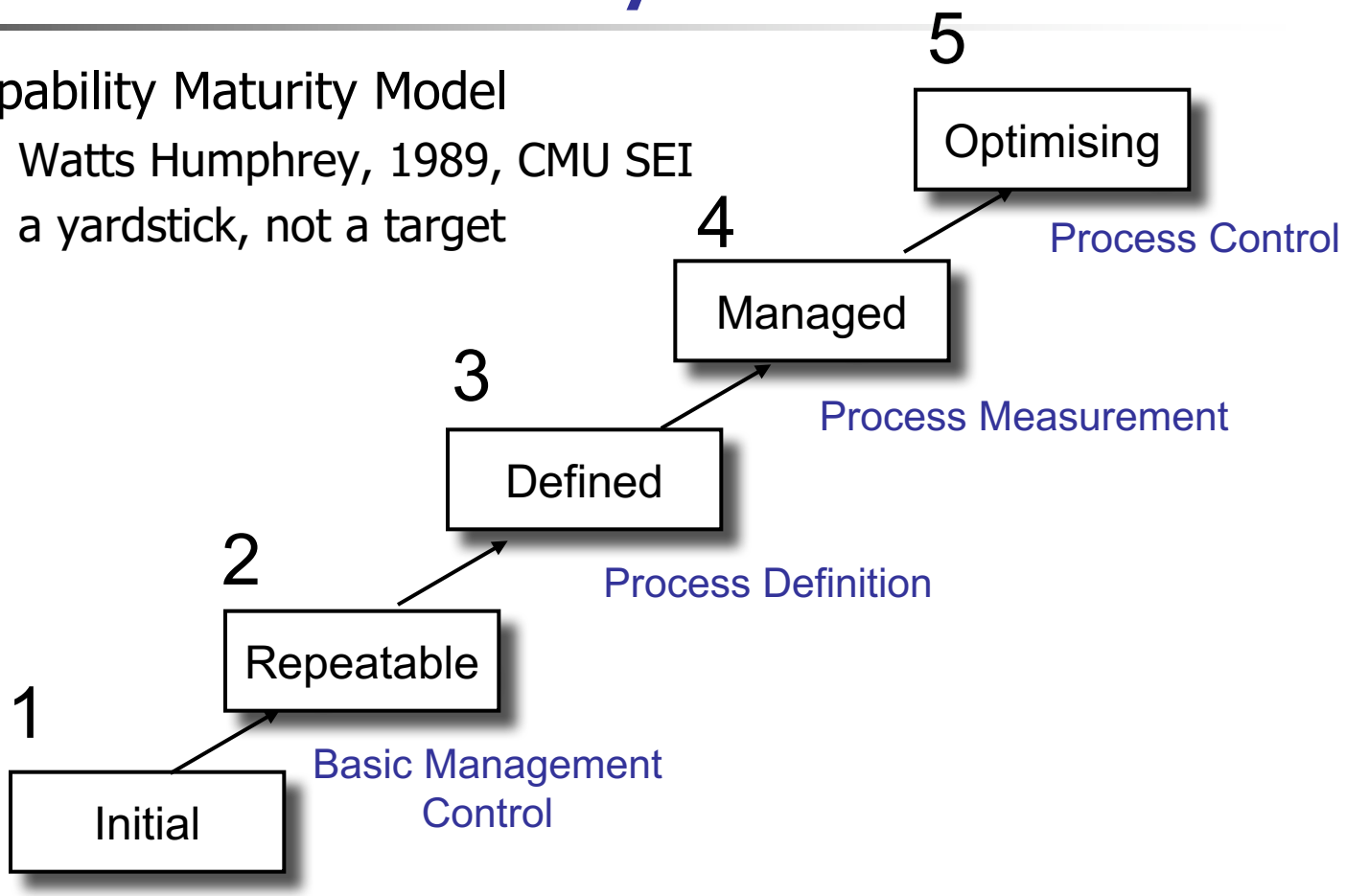
Process Management

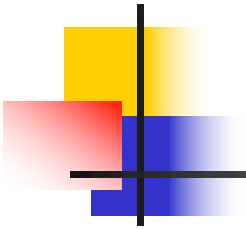
- Select a process model
  - to fit the product: wholistic, incremental, unknown
  - to match customer availability: continuous, staged, limited upfront availability
  - to fit the project environment: large scale, coordinated; small scale, prototyping
- Follow the process model
  - plan a set of stages, deliverables
  - modify process to suit project constraints
  - adapt and improve process in the light of experience: Capability Maturity Model [Humphrey, 1989]

Process Maturity

Capability Maturity Model

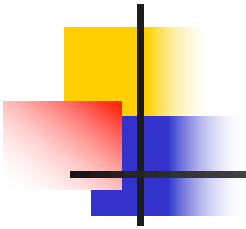
- Watts Humphrey, 1989, CMU SEI
- a yardstick, not a target





Project Management

- Many large software projects
  - are delivered late;
  - do not work properly;
  - are over budget; and
  - do not meet the customer's requirements
- Some projects are not delivered at all:
  - The bill for failed software projects in the US is estimated at upward of $75bn per annum [Computer Weekly]
  - Many of these failures can be attributed to the management of the software development process.



Risks to Mitigate

- Failure to understand the customer's needs
- The project scope is poorly defined
- Changes are poorly managed
- The supporting technology changes
- Business goals are changing
- Unrealistic deadlines are set
- Resistant users
- Losing the sponsorship (funding, company champion)
- Lack of skilled people in the software team
- Managers/developers do not use best practices

Costs of Mismanagement

- Requirements analysis is:
  - one of the most critical parts of software development
  - the hardest part to get right, regardless of methodology
- If the analysis is wrong, you may have to:
  - modify the software specification
  - adapt the software design
  - repair the software implementation
  - generate new tests and apply them
  - update the documentation
  - recall products already sold

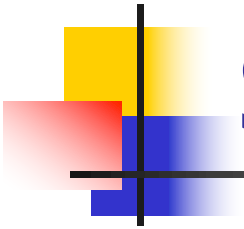
Costly and time consuming

Disaster!

- Fixing a requirements error may cost 100x as much as an implementation error!
  - capturing the requirements is absolutely critical

Mini-Lab: ATM Function Points

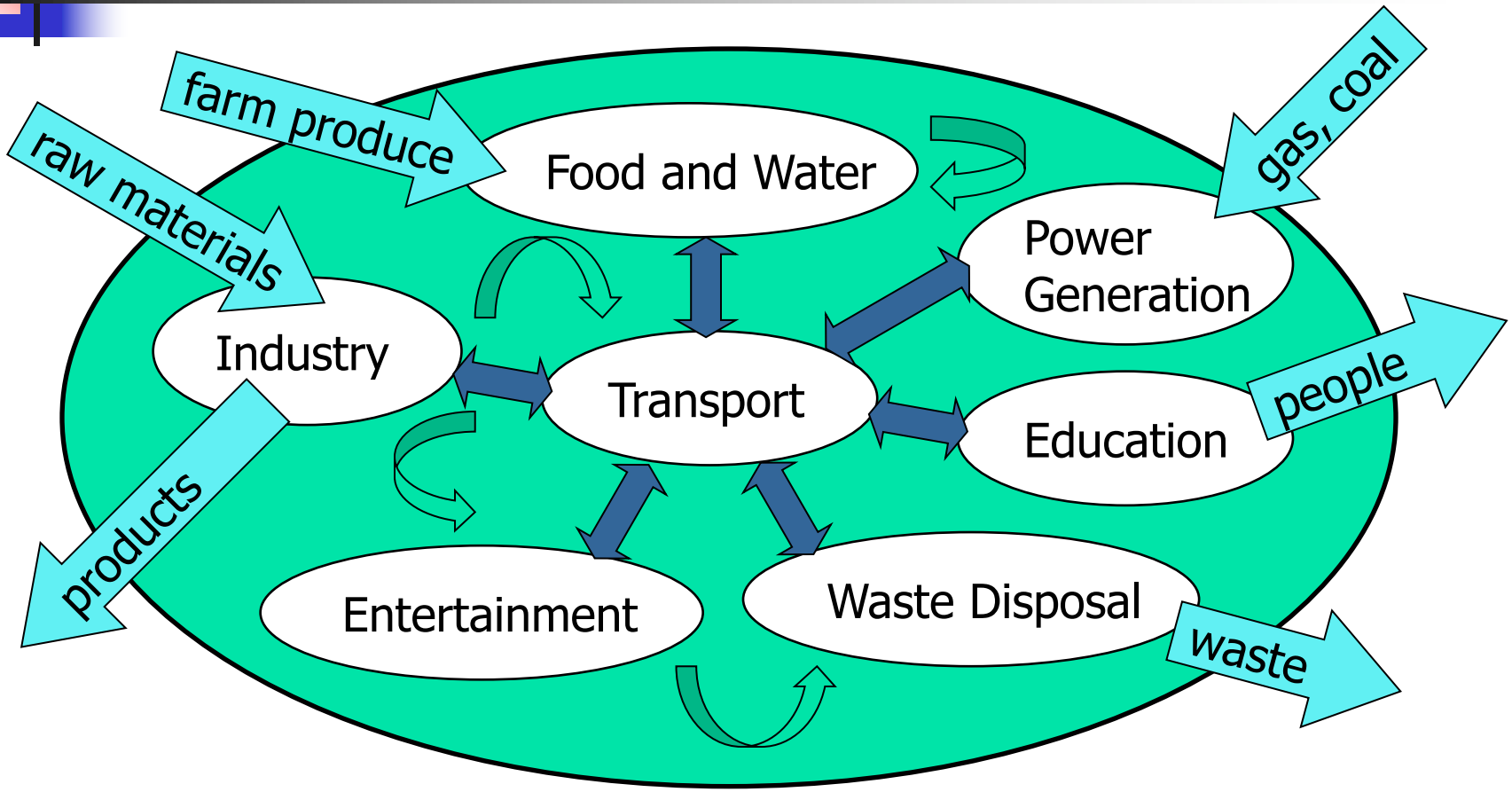
- Automated Teller Machine
  - ATM: the "hole in the wall" bank terminal and cash dispenser
  - purpose: to relieve the workload of cashiers (bank "tellers") and offer customer services
- What are the main function points?
  - Which functions are essential?
  - Which functions are possible?
- Which functions are harder to deliver?
  - Score each function on 1..3 for difficulty
  - Give reasons why some functions are harder/easier

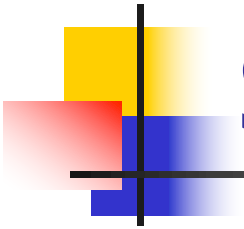


Systems

- A system is a complex whole
  - made up of many collaborating parts, or subsystems
  - the parts all work together to achieve some goal
  - has self-regulating control: feedback/feed forward
  - has emergent (integrative, synergistic) properties
    - "more than the sum of its parts" – not directly dependent
- A system exists in a context
  - separated from the environment by a boundary
  - has inputs from, and outputs to, the environment
- Example systems
  - a city – what are the parts? the goal?
  - the human body – what are the parts? the goal?

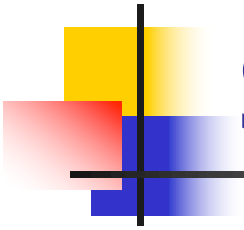
City as System





Software Systems

- Exist in a business context
  - goal is to support the business, raise revenues
  - core activity – eg: manufacture, process control
  - subsidiary activity – eg: sales, invoicing, personnel
    - information systems – the majority of software systems
- Interact with other systems
  - interact with physical (paper-based) or human systems
  - interact with legacy (outdated) software systems
- Questions in systems development
  - will the new system bring real benefits?
  - how to integrate with physical/legacy systems?
  - should physical/legacy systems be replaced?



System Requirements

- Functional requirements
  - What will the system do?
  - What must the users accomplish?
- Non-functional requirements
  - How well must the system deliver?
  - What performance goals are there?
  - What physical constraints exist?
- Usability requirements
  - How easy must the system be to use?
  - What styles of interaction are anticipated?

Study: ATM Requirements

[http://www.math-cs.gordon.edu/local/courses/cs211/ATMExample/]

The software to be designed will control an automated teller machine (ATM) having a magnetic stripe reader for reading an ATM card, a **customer console (keyboard and display) for interaction with the customer**, a slot for depositing envelopes, a dispenser for cash (**in multiples of $20**), a printer for **printing customer receipts, and a key-operated switch to allow an operator to start or stop the machine**. **The ATM will communicate with the bank's computer** over an appropriate ASDL link.

The ATM will service one customer at a time. A customer will be required to insert an ATM card and enter a personal identification number (PIN) - both of which will be sent to the bank for validation as part of each transaction. The customer will then be able to perform one or more transactions. The card will be retained in the machine until **the customer indicates** that he/she desires no further transactions, **at which point it will be returned**.

Colours distinguish functional, non-functional, and usability requirements. (answer available in the next slide)

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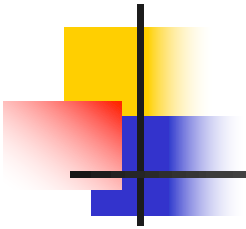
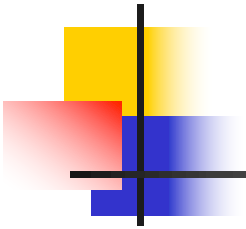


Functional Requirements

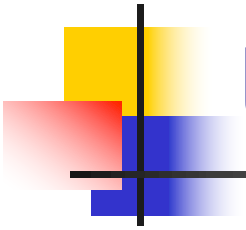
- Description of the processing done by the system
  - describe all input and output relationships
  - behaviour for all possible inputs (correct and incorrect)
  - consider all aspects of expected user interaction
  - describe the data that must be produced by the system
- Description of the main functions of the system
  - complete and consistent, expressed in a precise way
  - identify and try to resolve logical inconsistencies, especially in large systems (hard to avoid)
  - may be expressed as essential or desirable requirements



Non-functional Requirements

- Product requirements
  - performance (speed, latency), reliability, portability
  - constrained by hardware on which the system will run
- Organisational requirements
  - conform to policies and procedures within the business
- External requirements
  - legal and ethical requirements (security, confidentiality)
  - how the system interacts with other systems

[this classification from Sommerville]



Usability Requirements

- Is the system a pleasure to use?
- User-centred design
  - is the user skill level correctly pitched?
  - what tasks must each user undertake?
  - is the sequence of tasks logical and intuitive?
- Situational factors
  - how ergonomic, fitting with working practices?
  - how robust to incorrect data entry?
- Acceptance criteria
  - how shall we test if a system is a success?

Study: Requirements Form

Requirement: Validate PIN

Type: Functional

Description: Validates the PIN entered by the user against the central record held on the bank system. Returns an output indicating that the PIN is either correct or incorrect. If the PIN is correct then the session can continue. If the PIN is not correct then the session will terminate, and the card should be returned to the user.

Inputs: user's PIN, record of user's bank account.

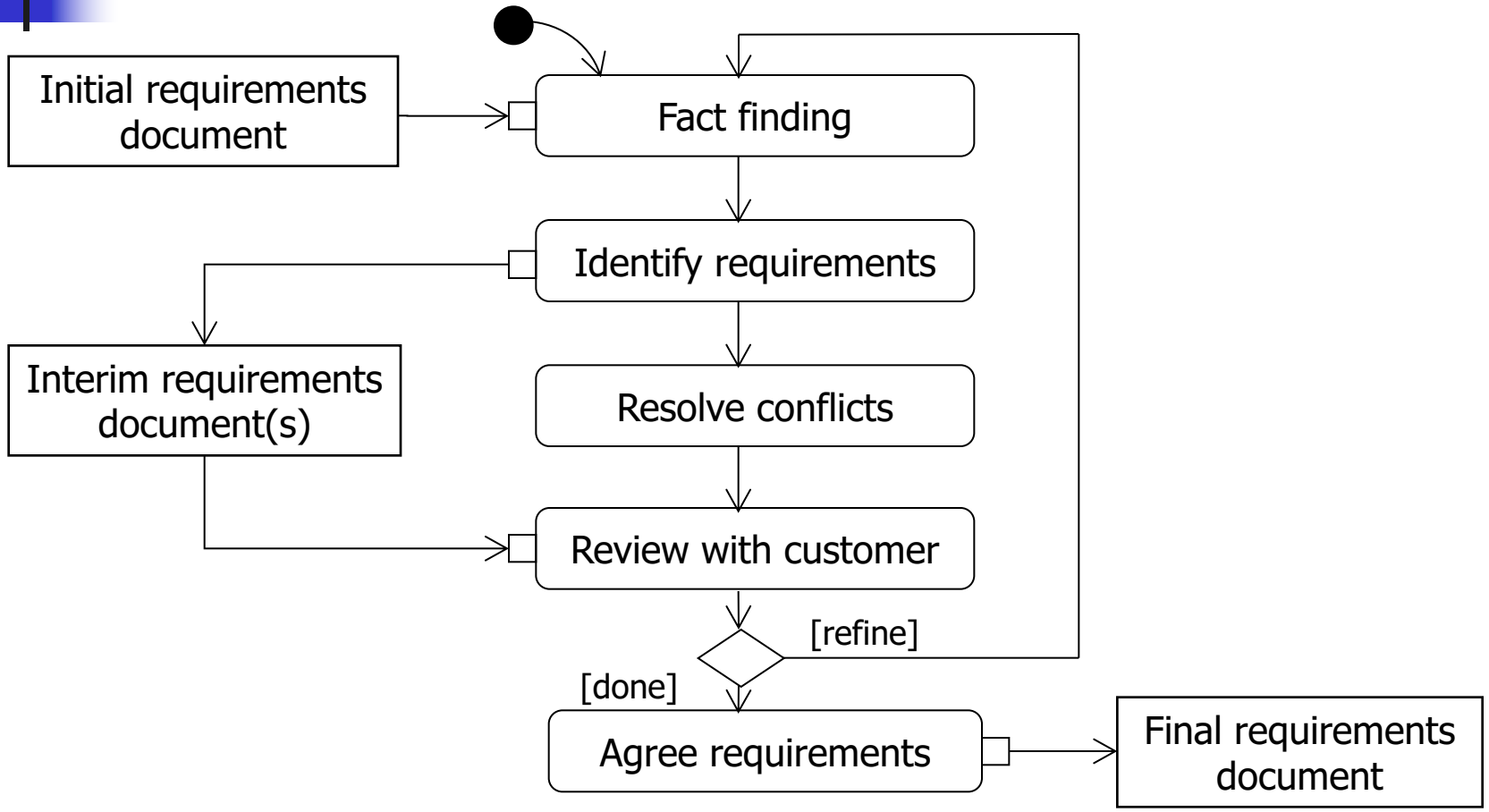
Outputs: PIN correct, PIN incorrect.

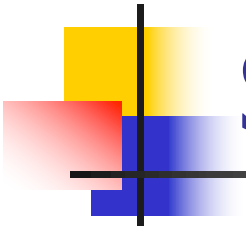
Criticality: A key component – other ATM functions depend on this.

Risk: Very high.

Dependencies: User input, communication with bank system.

The Elicitation Process



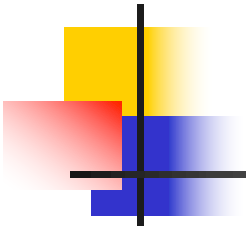


Starting Points

- Customer may only have a general business vision
  - Opportunity-driven: an idea to capture a new market
  - Necessity-driven: a solution to avert business failure
- Customer may define initial requirements
  - Perhaps as part of a competitive tendering process
  - Can be too abstract, high-level, imprecise, incomplete
  - Can have a biased viewpoint, make tacit assumptions
  - Can focus narrowly on one make-or-break issue
- Developer must compensate for this
  - Wider scope may deliver many additional business benefits
  - Analysis must therefore include the whole business context

Fact Finding

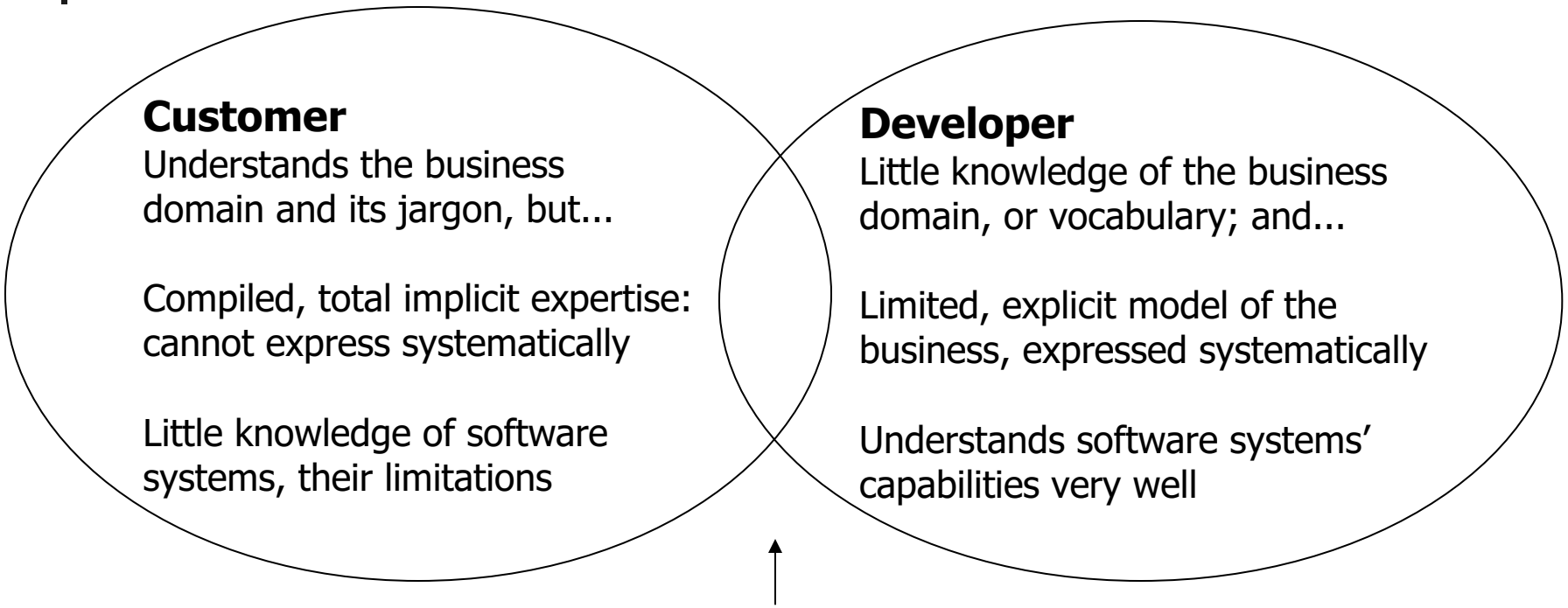
- Background reading
  - documentation, procedures, job descriptions, and reports
  - provides contextual information – to educate the developer!
- Interviewing/workshops
  - most widely used technique, but requires skill and sensitivity
- Observation
  - get quantitative data, eg: typical time to complete a task
  - useful for observing responses to exceptional situations
- Document sampling
  - paper documents, screenshots: illustrate information flow
- Questionnaires
  - an economical way to collect data, but hard to do well



Elicitation Techniques

- Interviewing
  - use non-directive interviewing style
    - let the stakeholders lead, in their own terms
    - use brief prompts only, “what”, “why”, “who”, etc.
    - don’t use forced-choice, multi-part questions
    - reflect back what is captured, for confirmation
  - stakeholders must own the result
- Workshops
  - collect multiple stakeholder viewpoints
    - exaggerate extreme viewpoints to see conflicts
  - balance, or resolve conflicts of interest
    - choose the solution which preserves balance of power

Communication Issues



How can we maximise this overlap?

Perception Experiment

What do you see in this image ?

Psychological Bias

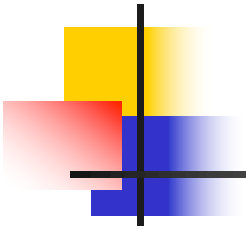
- The customer has:
  - a total, but implicit ("compiled") knowledge of the business
  - only limited ability to articulate this systematically
  - a narrow focus ("tunnel vision") on the make-or-break criterion
- The developer has:
  - an incomplete, but explicit appreciation of the business
  - a tendency to produce over-simplified but systematic models
  - a global focus on the entire business
- How to maintain focus:
  - don't impose structure on the customer – let him/her lead
  - use short prompts: "who does X?", "what else does Y do?"
  - capture the breadth of the business, not a few functions in depth
  - active listening: "so you need X", "have I understood Y?"

Workplace Politics

- The stakeholders
  - wield power: success or failure depends on their acceptance
  - have vested interests in how their job-roles are supported
  - new system may affect their relative status, importance
  - poor understanding, or fear of technology affect take-up
  - management can impose wrong system for political reasons
  - industrial relations can influence system adoption
- Viewpoint analysis
  - get stakeholders to express their "bluesky wishlists"
  - encourage extreme, caricatured, or selfish viewpoints
  - reveal conflicts, stimulate discussion in a humorous way
  - defuses tension, achieves resolution

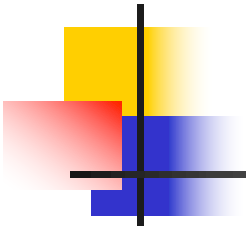
Requirements Drift

- Requirements always change during the capture process
  - modelling the system highlights unforeseen issues
  - the business environment may change
  - the software platform may change
- Prioritize requirements
  - identify stable, vs. volatile requirements (change more often)
  - classify as essential, necessary, desirable and optional
- Agree staged delivery schedule
  - essential requirements – without which the system is pointless
  - necessary requirements – on which essential features depend
  - desirable requirements – may be dropped if time runs out
  - optional requirements – not considered unless time permits



Requirements Review

- The requirements review
  - should be a regular event
  - should involve all stakeholders
- Should check for
  - Validity – proposed system meets the customer's needs
  - Consistency – no logical contradictions in requirements
  - Completeness – no gaps, or missing requirements
  - Coherence – no conflict between functional/non-functional
  - Feasibility – can deliver on time and within budget
  - Verifiability – can test system against these requirements
- Faults in requirements
  - at best, expensive to fix
  - at worst, impossible to fix



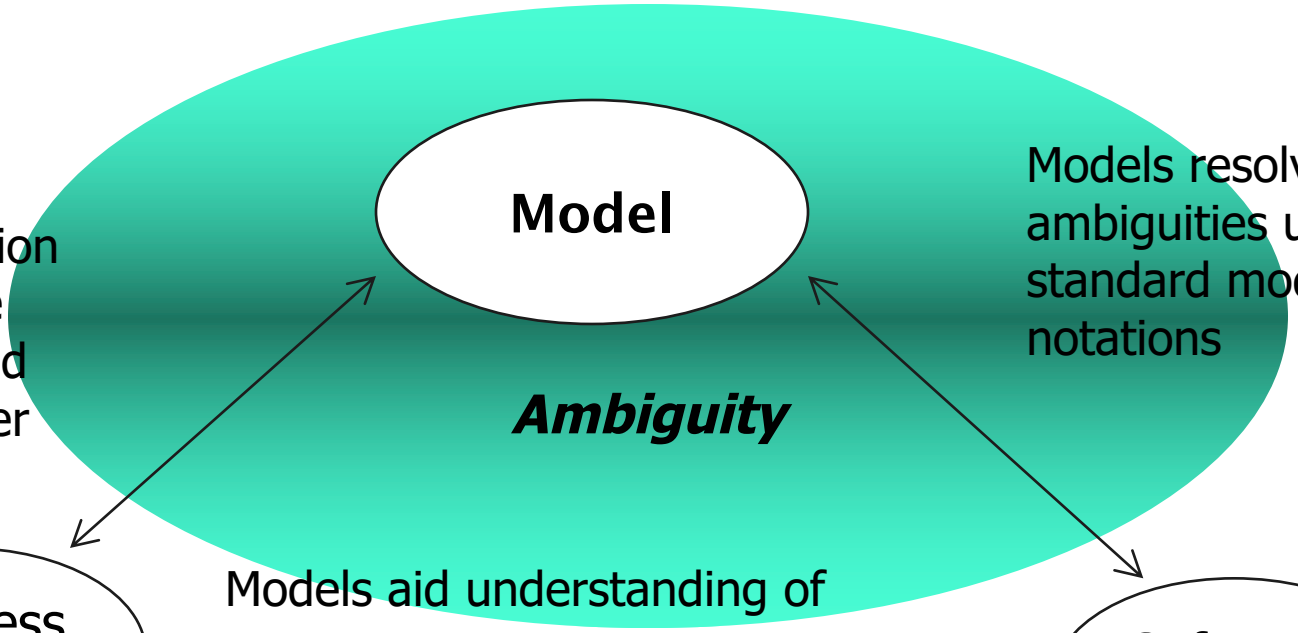
Mini-lab: Viewpoint Analysis

- For the ATM case study
  - imagine you are commissioning the first ATM cash dispenser
  - conflicts over availability, security of money held in banks
- Caricature extreme stakeholder positions
  - Bank Manager – responsible for security
  - Cashier – manages customer transactions
  - Customer – access to money
- How does the solution balance concerns?
  - what is the chosen solution?
  - how does it balance concerns of each stakeholder?

Coordination Issues

- Small Projects
  - capable of being understood by all the team
  - developers rotate easily onto different parts
  - good communication within small groups
- Large Projects
  - no one person understands the whole
  - increased importance of modelling, abstract or partial views of the system, decomposition into subsystems
  - developers handle particular modules, subsystems
  - communication good within subdivisions, but poor across the project as a whole
  - increased reliance on documentation, designs, interfaces
  - increased use of version control (eg CVS), change tracking

Why Build Models?



Models aid communication between the customer and the developer

Models resolve ambiguities using standard modelling notations

Business process

Software system

Models aid understanding of

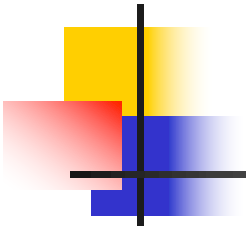
- the functionality of the system
- how well a software system matches the desired process

Models and Management

- Models help with coordination
  - abstract views of the whole system
  - detailed views of subsystems
  - models are platform-independent
- Models help with communication
  - offer a communication framework within/across teams
  - clarify and document structures and relationships
  - reveal/generate new ideas and possibilities
- Models help with the product
  - support decomposition, modular design
  - support code generation using CASE tools
  - support QA scenarios, test generation

Unified Modelling Language

- UML 2.4 is the standard design notation for documenting modern software systems (OMG, Jan 2013)
- UML is a descriptive modelling language – can be used with different software lifecycle processes
- UML is a precise modelling language – like circuit diagrams
  - UML syntax – expresses what diagrams are legal
  - UML semantics – expresses what diagrams mean
- UML supports different stages of the lifecycle
  - analysis models of the perceived world
  - design models documenting implementations
- UML is learned by every software engineer
  - major focus of this course – accurate usage of UML

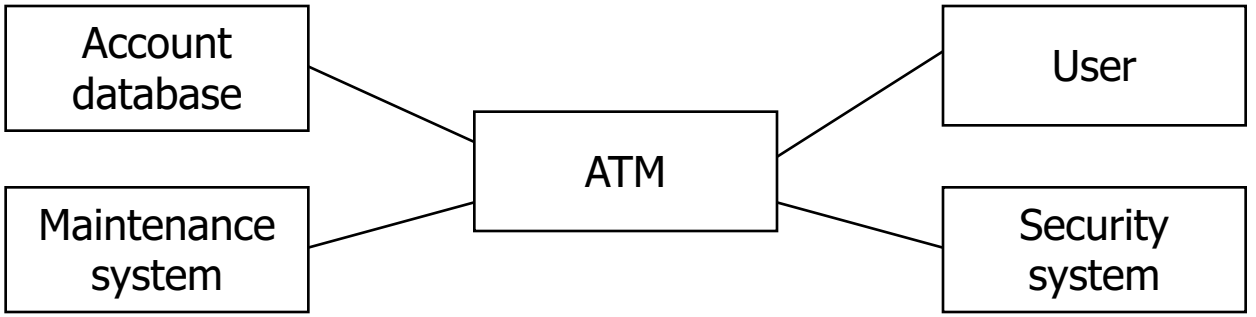


Kinds of Model

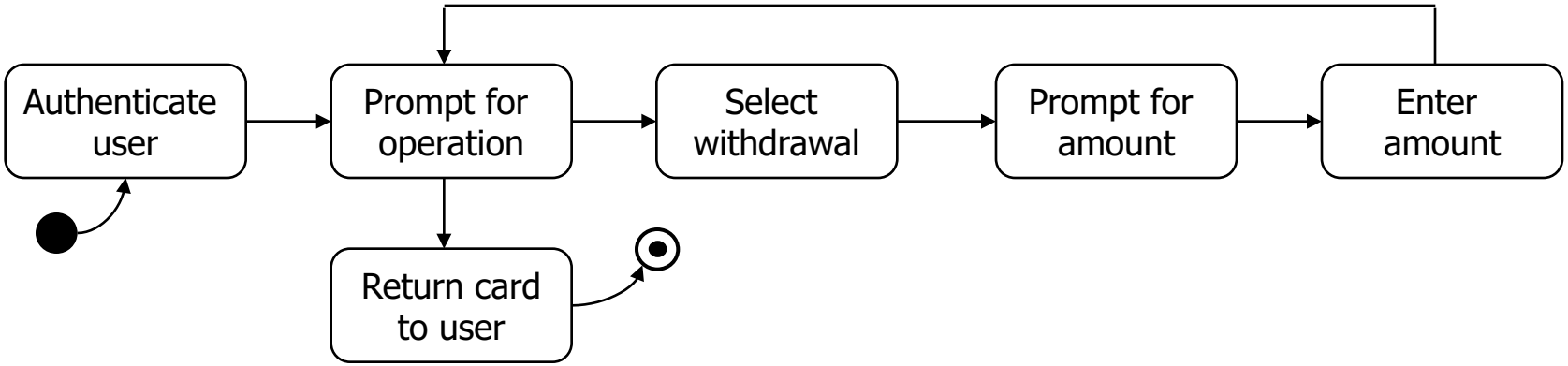
- Document the stages of the lifecycle
  - analysis model – abstract, what the system does
  - design model – concrete, how the system does it
- Different abstract views of a system
  - **process view** – what actions are performed
    - eg: UML Use Case Diagram
    - eg: UML Activity Diagram
  - **data view** – what information is manipulated
    - eg: UML Class Diagram
  - **time view** – the order in which actions are done
    - eg: UML State Machine Diagram
    - eg: UML Sequence Diagram

Examples of UML Models

Class diagram: structural model with little detail



Activity diagram: behavioural model with some detail

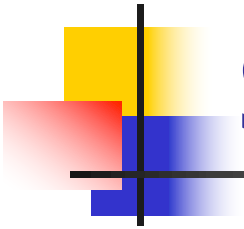


UML 2.x Reference

- OMG UML Website – the gold standard
  - http://www.uml.org/ - general portal
  - http://www.omg.org/spec/UML/2.4/ - current version
    - dense infrastructure and superstructure docs
- IBM White Papers
  - http://www.ibm.com/software/rational/uml/
    - *Rational Edge* articles by Don Bell, white papers
- Books
  - The UML Users Guide, 3rd ed., G Booch et al.
  - UML Distilled, 3rd ed., M Fowler.
  - UML in a Nutshell, O'Reilly pubs.

UML 2.x Tools

- Visual Paradigm
  - http://www.visual-paradigm.com/ - UML 2.2
  - free community edn., also 30-day trial edn.
- Sparx Systems
  - Enterprise Architect - UML 2.1; also good tutorial
  - http://www.sparxsystems.com.au/resources/uml2_tutorial/
- Eclipse/IBM/Rational
  - Rational Software Architect, Eclipse-based tool
  - UML 2 Tools – open source project, incomplete
- Microsoft Visio – UML 2.2 templates



Summary

- Project management is about managing people, the product, the process and the project, to minimize risk
- Software systems interact with people- and paper-based business systems and with legacy computer systems
- Requirements are elicited in cycles and classified into functional, non-functional and usability requirements
- The customer and developer have different mind-sets – bridge the communication gap using non-directive interviewing
- Stakeholders have different vested interests – resolve workplace conflicts through workshops and viewpoint analysis
- UML 2.4 is the standard design notation – UML models used to coordinate development throughout lifecycle