
Interactive system specification

Interactive system definition

- ◆ Interactive systems can be defined as the class of systems whose operations involve a significant degree of user interaction.
- ◆ Common media for interaction include the keyboard, voice recognition, video, touch screen, mouse etc.
- ◆ The process of formulating the software requirements for such systems must take into account the important issues associated with such systems.

Issues to be taken into account for interactive systems

- ◆ *User interface.* The ability to model and represent user interface requirements
- ◆ *User classes.* Interactive systems often have varied classes of users with varying (potentially conflicting) requirements and expectations.
- ◆ *Other systems.* Interactive systems may interface with other systems in their environment.

Requirement issues for interactive systems

- ◆ *Indirect system concerns.* These are issues related to system design and implementation, the **influence of the system on the organisation** and the **system's influence on the environment**.
- ◆ *Quality of service.* The **closeness of the system to the end-user** lends special significance to quality of the service delivered. Quality concerns include:
 - Availability
 - Performance
 - Usability
 - Form of delivery

Using VORD to specify an interactive system

- ◆ The automated teller machine (ATM) is a good example of an **interactive system** as it embodies all the attributes discussed earlier.
- ◆ In the next discussion we will use the VORD method, to formulate the requirements of the ATM.
- ◆ VORD has been primarily developed to support the specification of interactive systems and focuses on the external entities that interact with the system or affect its development.

ATM requirements

- ◆ A simplified ATM contains an embedded software system to drive the machine hardware and to communicate with the bank's customer database.
 1. The system accepts customer requests and produces cash and account information, and provides for limited message passing and funds transfer.
 2. The ATM is also required to make provisions for major classes of customers, namely customers whose account is with the bank which owns the ATM (home customers) and customers from other banks who have ATM access (foreign customers).

ATM requirements (contd..)

3. ATM users are issued with a cash-card and a personal identification number (PIN) that they must use to access the ATM services.
4. Home customers receive all the services provided by the ATM. Foreign customers can only receive a subset of ATM services (i.e. they can only access the ATM to withdraw cash).
5. The ATM is also required to update the customer account database each time there is a cash withdrawal or funds transfer.
6. All the services provided by the ATM are subject to certain conditions, which can be considered at different levels.

ATM requirements (contd.)

- 6.1 The top level sets out conditions necessary for accessing the services. These include a valid ATM cash-card and correct personal identification number (PIN).
- 6.2 The next level is concerned with service requests and is subject to the availability of particular services.
- 6.3 At lowest level, all services provided by the ATM are subject to specific conditions set out for their provision. For example, customers can only withdraw cash to a maximum of their balance.

VORD

- ◆ The requirements model adopted by VORD is service-oriented where viewpoints are analogous to clients in a client-server system.
- ◆ The system delivers services to viewpoints and the viewpoints pass control information and associated parameters to the system.
- ◆ Viewpoints map to classes of end-users of a system or to other systems interfaced to it.

VORD (contd.)

- ◆ A VORD viewpoint is an entity outside the system that generates a requirement (i.e. a requirement source).
- ◆ A viewpoint can be a system user, a sub-system interfaced to the intended system or an organizational concern.
- ◆ Viewpoints are structured into a classification hierarchy to accommodate the variations in user requirements.

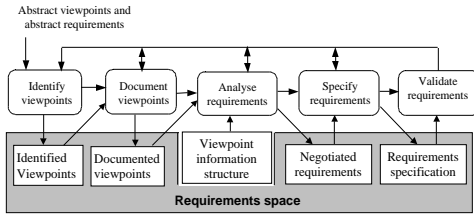
VORD (contd.)

- ◆ VORD viewpoints fall into two classes:
 1. *Direct viewpoints* correspond directly to clients in that they receive services from the system and send control information and data to the system.
 - Direct viewpoints are either system operators/users or other sub-systems, which are interfaced to the system being analysed.
 2. *Indirect viewpoints* have an 'interest' in some or all the services which are delivered by the system but *do not* interact directly with it.
 - Indirect viewpoints may generate requirements, which constrain the services delivered to direct viewpoints, and the system development process.
 - Indirect viewpoints vary radically. They may include engineering viewpoints, organizational viewpoints and external viewpoints.

VORD (contd.)

- ◆ The VORD method is based on three main iterative steps, namely:
 1. Viewpoint identification and structuring
 2. Viewpoint documentation
 3. Viewpoint requirements analysis, specification and validation

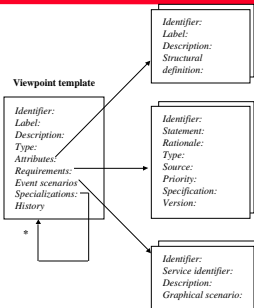
VORD process model



Viewpoint template

- ◆ VORD uses standard templates to record viewpoint and requirement information. A viewpoint template comprises:
 - A viewpoint identifier number
 - A viewpoint name or label
 - Description of the role of the viewpoint in the problem domain
 - A viewpoint type (Traces the viewpoint to its parent class)
 - Attributes that characterize the viewpoint in the problem domain. Attributes represent the control information supplied by the viewpoint to the system.
 - Event scenarios that describe the interaction between the viewpoint and the system.
 - Viewpoint specializations or subclasses.
 - Viewpoint history that describes the evolution of viewpoint requirements

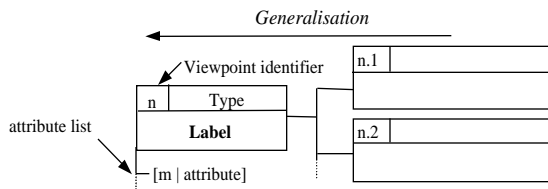
Viewpoint template



Viewpoint notation

- ◆ VORD uses a simple graphical notation to represent a viewpoint:
 - A rectangular box represents the viewpoint.
 - The viewpoint identifier is shown on the top left-hand corner of the box and the viewpoint label in the lower half of the box.
 - The viewpoint type is shown on the top right half of the box.
 - A viewpoint attribute is indicated by a vertical line dropping from the left side of the box.
 - Viewpoint specializations or sub-classes are shown from left to right.
- ◆ The notation is augmented with viewpoint information templates

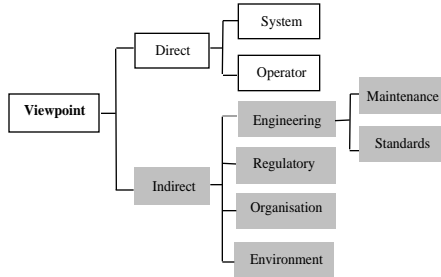
Viewpoint notation



Identifying ATM Viewpoints

- ◆ The process of understanding the system under analysis, places a lot of reliance on the 'system authorities'
 - These are people or documents with an interest or specialist knowledge of the application domain.
 - They include system end-users, system procurers, system engineers and documentation of existing system(s).
- ◆ VORD has generalised these 'system authorities' into a set of *abstract* viewpoint classes, which can be used as a starting point for finding viewpoints specific to the problem domain.

Abstract viewpoint classes



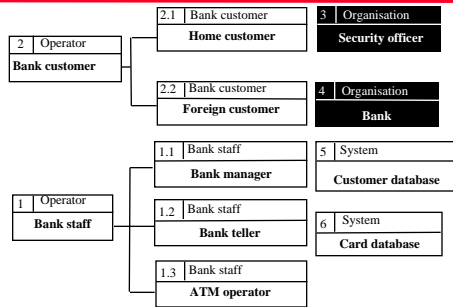
Using abstract viewpoints to identify application specific viewpoints

1. Prune the abstract viewpoint class hierarchy shown in , to eliminate viewpoint classes which are not relevant for the specific system being specified. In the ATM example, let us assume that there is no external certification authority and no environmental effects. We therefore do not need to look for viewpoints under these headings.
2. Consider the system stakeholders i.e. those people who will be affected by the introduction of the system. If these stakeholders fall into classes which are not part the organisational class hierarchy, add these classes to it.
3. Using a model of the system architecture, identify system viewpoints, i.e. viewpoints representing other systems. In the example of the ATM we can identify two main sub-system, the *customer database* and card database. We note that architectural models of systems almost always exist because new systems must be integrated with existing organisational systems.

Using abstract viewpoints to identify application specific viewpoints

4. Identify system operators who use the system on a regular basis, who use the system on an occasional basis and who request others to use the system for them. All of these are potential viewpoints. We can identify four instances of direct viewpoint in this example namely the *bank customer* (regular), *ATM operator* (occasional), the *bank manager* (occasional).
5. For each indirect viewpoint class which has been identified, consider the roles of the principal individual who might be associated with that class. For example, under the viewpoint class 'customer', we might be interested in the roles of 'regulations officer', 'maintenance manager', 'operations manager' etc. There are often viewpoints associated with these roles. In the ATM example, there are many possible indirect viewpoints but we will confine our analysis to a security officer and a organisational policy, represented by the bank viewpoint.

ATM viewpoints



Bank staff viewpoint documentation

Viewpoint		Requirement		
Ident. #	Label	Description	Type	Source VP
1	Bank staff	1.1 Provide access to administrative services based on valid staff PIN and the access permissions set out for the bank staff	sv	4
1.1	Bank manager	1.1.1 Provide transaction reports to bank manager.	sv	1.1
		1.1.2 The bank manager requires transaction reports to be provided on a daily basis	sv	1.1
1.2	Bank teller	1.2.1 Provide for cancellation of cash card in the event of lose or cancellation of card by bank.	sv	4
		1.2.2 Provide for card cancellation effected in no more than 3 minutes from request.	nf	4
1.3	ATM operator	1.3.1 Allow for system startup and shutdown based on valid staff PIN from ATM operator	sv	4
		1.3.2 Provide a facility for paging operator when funds are low in ATM	sv	4
		1.3.3 Failure rate of the paging service should not exceed 1 in 1000 attempts	nf	3

Bank customer viewpoint documentation

Viewpoint		Requirement		
Ident. #	Label	Description	Type	Source VP
2	Bank customer	2.1 Provide access to ATM services based on valid cash-card, valid PIN and access permissions set out for the bank customer	sv	4
		2.2 Provide for withdrawal of cash by bank customers	sv	4
		2.3 Cash withdrawal service should be available 999/1000 requests	nf	2
		2.4 Cash withdrawal service should have a response time of no more than 1 minute	nf	2
		2.5 At least 50% of the currency notes in the ATM should be 5 and 10 dollars notes.	nf	2
2.1	Home customer	2.1.1 Provide home customers with the facility to transfer funds	sv	4
		2.1.2 Provide home customers with the facility to obtain a printout of their last five transactions	sv	4
		2.1.3 Provide for balance enquiry by bank customers	sv	4
2.2	Foreign customer			

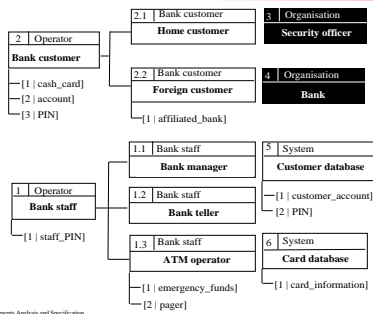
Documenting other viewpoints

Viewpoint		Requirement		
Identif. er.	Label	Description	Type	Source VP
3	Security officer	3.1 All system security risks shall be identified, analysed and minimised according to the ALARP (as low as is reasonably possible) principle.	nf	4
		3.2 Standard encryption algorithms shall be used.	nf	4
		3.3 System shall print paper record of all transactions	nf	4
4	Bank	4.1 Complete system maintenance shall be done once every month.	nf	4
		4.2 Cash withdrawal service should be available in 90% requests for the service.	nf	4
		4.3 Cash withdrawal should have a response time of no more than 2 minutes from the time of request	nf	4
		4.4 System shall be operational in 6 months	nf	4
		4.5 System should accommodate all current currency notes	nf	4
5	Customer database			
6	Card database			

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Documenting viewpoint attributes



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Prioritizing requirements

- ◆ The most obvious way to prioritise requirements, is to base priorities on the relative importance of the requirements with respect to the viewpoint
- ◆ This fails to take into account the resources needed to deliver the requirement and the risk associated with the requirement
- ◆ VORD includes a simple weighting scheme that organises weightings around importance, resources and risk
- ◆ Each requirement is weighted as high(H), medium (M) or low(L) in relation to each of the three factors on a scale of 1-3

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Incorporating risk and resources

- ◆ The factors shown below may vary across applications and organizations

Weighting	High(H)	Medium(M)	Low(L)
Factor			
Importance	3	2	1
Resources required	1	2	3
Risk involved	1	2	3

Non-functional requirements

- ◆ Non-functional requirements *translate to constraints on viewpoint services*, attributes and the development process in general
- ◆ The next table shows *how* the constraints affect various viewpoint services.
 - The table also provides an indication of the coverage of the constraints, for example, global constraints are associated with all customer and other services
 - Specific constraints are shown with respect to each affected service.
 - The coverage of the constraints provides an important input to the analysis process.

Constraints on services

Viewpoint Service	
Identifier	description
	Constraint
All services	4.1 Complete system maintenance to be done once every month 4.4 System must be operational in 6 months
1.1.1 Transaction reports	1.1.2 Transaction reports must be provided on a daily basis
1.2.1 Card cancellation	1.2.2 Service should have a response time of no more than 3 minutes
1.3.2 Operator paging when funds are low in ATM	1.3.3 Failure rate of the paging service should not exceed 1 in 10000 attempts
2.2 Cash withdrawal	2.3 Cash withdrawal service should be available 999/1000 requests 2.4 Cash withdrawal service should have a response time of no more than 1 minute 2.5 At least 50% of the currency notes in the ATM should be 5 and 10 dollars bills. 4.2 Cash withdrawal service should be available 9/10 requests for the service 4.3 Cash withdrawal should have a response time of no more than 2 minutes

Constraints on attributes

Viewpoint Attribute		
Identifier	Description	Constraint
1.1	staff_PIN	3.2 standard bank encryption algorithms must be used
2.1	cash_card	3.2 standard bank encryption algorithms must be used
2.3	PIN	3.2 standard bank encryption algorithms must be used should be four characters long
1.3.1	emergency_funds	2.5 At least 50% of the currency notes in the ATM should be 5 and 10 dollar bills.
5.1	customer_account	
5.2	PIN	
6.1	card_information	

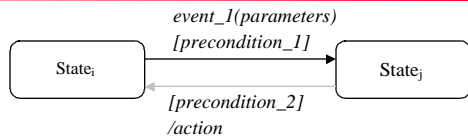
Modeling system behavior

- ◆ VORD uses event scenarios to model dynamic system behavior.
- ◆ An event scenario is defined as a sequence of events together with exceptions which may arise during the interchange of information between a viewpoint and the intended system.
- ◆ Viewpoint events are a reflection of control requirements as perceived by the user.
- ◆ VORD uses an extended state transition notation to model event scenarios.

Event scenario rules

- ◆ A normal sequence of events may have exceptions at various points in the event sequence.
- ◆ At the system level, exceptions cause a transfer of control to exception handlers.
- ◆ Exceptions are shown in grey arrows and normal sequences in black.
- ◆ A transition is triggered by an event and/or preconditions, which must be satisfied before the transition, can take place.
- ◆ An event may include an optional set of parameters, and may be accompanied by a set of actions.

Scenario notation



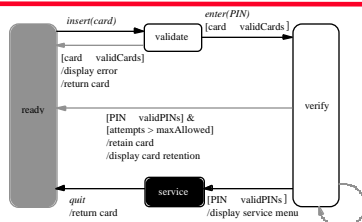
Note

- Normal sequence
- - -> Exception sequence

Event scenario for accessing ATM services

- ◆ Before a customer can access an ATM service, the system needs to be in the service ready state shown by the grey rectangle
- ◆ When the system is in the ready state, it sets out the preconditions necessary for accessing the ATM services, namely:
 - A valid cash card and,
 - A correct PIN
- ◆ These conditions must be satisfied before the system can go into the service state.
 - In the service state the system displays the available services.

Event scenario for accessing ATM services



Note

- attempts = number of attempts at PIN
- maxAllowed = maximum allowed attempts
- validPINs = set of valid PINs
- validCards = set of valid cash-cards

- enter(PIN)
[PIN validPINs] &
[attempts < maxAllowed]
/display error

Formulating user interface requirements

- ◆ User interface considerations are important in formulating the requirements of interactive systems
- ◆ They are highly subjective and difficult to establish through a structured process of requirements analysis
- ◆ In many cases, user interface requirements can only be determined through experiment and prototyping
- ◆ However there is a close relationship between user interface requirements and viewpoints

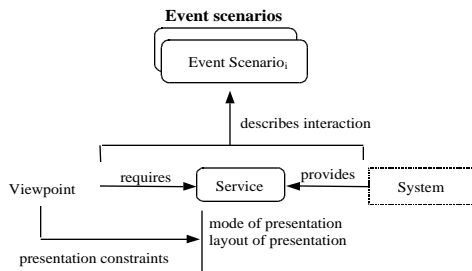
User interface requirements and viewpoints

- ◆ User interface requirements describe the mode and presentation of viewpoint services.
- ◆ They can therefore be represented as constraints on viewpoint services
- ◆ This process is, in turn, informed by viewpoint event scenarios which describe the interaction between the viewpoint (in this case the user) and the system

User interface requirements and viewpoints (contd.)

- ◆ A service is provided through the interaction between a viewpoint and the system.
- ◆ The interaction is described using event scenarios
- ◆ The viewpoint requiring the service may impose certain constraints on the way the service is presented
- ◆ These may include constraints on mode of the presentation and how the presentation is organised (layout).

User interface requirements and viewpoints (contd.)



Requirements analysis

- ◆ The objective of viewpoint requirements analysis is establish that viewpoint requirements are correct and 'complete'.
- ◆ There are two main stages to this analysis.
 1. Correctness of viewpoint documentation. The viewpoint documentation must be checked to ensure that it is consistent and that there are no omitted sections.
 2. Conflict analysis; conflicting requirements from different viewpoints must be exposed and resolved.

Checking viewpoint documentation

- ◆ This involves verifying that a viewpoint has been correctly and completely documented.
- ◆ We have defined viewpoint as a entity consisting of a number of components (attributes, requirements etc).
- ◆ Although some of this information must appear on all viewpoints, other information may be omitted depending on whether the viewpoint is direct or indirect.

Conflict analysis (contd.)

- ◆ These type of conflicts can be exposed by:
 1. Analysing the constraints associated with a particular service, for consistency
 2. Analysing one viewpoint's requirements against other viewpoint (all requirements for contradictions).
- ◆ In addition to these specific viewpoint requirements, all individual requirements must be analysed against high-level organisational and other global requirements that define the general quality attributes of the intended system (e.g. safety, security..).

Conflict resolution and management

- ◆ Requirements conflict resolution and management is the subject of on-going research
- ◆ There is no simple way of automating all the aspects of conflict resolution.
- ◆ The checking model adopted by VORD is based on ensuring that information can be presented in a way that manual analysis is simplified.
- ◆ Individual requirements are checked against each other, and against the global requirements.

Example of ATM system conflict identification

Requirement 1	ID	2.3	4.1
	Description	Cash withdrawal service should be available in 999/1000 requests	Complete system maintenance must be done once every month
Requirement 2			
ID	Description		
2.3	Cash withdrawal service should be available 999/1000 requests	-	
2.4	Cash withdrawal service should have a response time of no more than 1 minute		
2.1.3	Provide for balance enquiry by bank customers		?
3.1	All system security risks must explicitly identified, analysed and minimised according to the ALARP (as low as is reasonably possible) principle.	c	
4.1	Complete system maintenance must be done once every month		-
4.3	Cash withdrawal should have a response time of no more than 2 minutes from the time of request		
4.4	System shall be operational in 6 months	c	

Service specification

- ◆ VORD supports the specification of viewpoint services in a variety of notations. This is particularly important for two reasons:
 1. The ability to represent the same requirement in different notations which are familiar to different people enhances communication and aids understanding.
 2. No one requirements notation can adequately articulate all the needs of a system. More than one specification language may be needed to represent the requirement adequately.
- ◆ If more than one notations is used to specify the same requirement, then it is important to ensure that the two specifications are consistent

Informal specification of the ATM cash withdraw service

Customer requests cash withdrawal

if any of the following conditions is true **refuse withdrawal**:

condition1: The requested amount exceeds customer balance.

condition2: The funds in ATM are less than requested amount

else do the following:

 dispense cash

 update customer account

endif

Formal specification using Z

Specification for cash withdrawal

```
CashWithdrawal
  PermitWithdrawal RefuseWithdrawal
```

Free types for cash withdrawal

```
FundStatus ::= adequate | inAdequate
AccountStatus ::= overdrawn | goodStanding
criticalLevel = 1000
accountNumber.0..106
```

Part of ATM requirements document

3.SPECIFIC REQUIREMENTS

Viewpoint

2.1 Home customer

A Description:
The home customer viewpoint represents the customers who belong to the home bank.

B Type
Operational

C Specialisations

Name	Reference	Date	Change Description	Rationale
2.1	Viewpoint	23/4/97	component created	N/A

E Requirements

E1 Services

2.2 Cash withdrawal

Description:
The ATM should provide a cash withdrawal service to all its customers to allow them to withdraw cash from the cash dispenser around the clock.

Source: e Bank

Priority: 5

Event scenario: (see page...)

Specification: 1. Informal (see page...)
2. Formal (see page...)

E2 Non-functional Requirements

2.3 Cash withdrawal availability

Description:
Cash withdrawal service should be available in 999/1000 requests

Source: e Bank customer

Priority: 9

Affected services: 2.2 Cash withdrawal

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Keypoints

- ◆ Interactive systems can be defined as systems whose operations involve a significant degree of user interaction
- ◆ To be effective, the requirements definition process must address usability, varied user requirements, environment, organisational, quality of service issues posed by these systems.
- ◆ A natural way to specify interactive systems is to specify the services which they provide for end-users and other systems

Keypoints

- ◆ VORD is based on viewpoints that focus on user issues and organisational concerns.
- VORD defines two main types of viewpoints; direct and indirect.
- System behavior is defined in VORD using event scenarios.
- Scenarios can be used to describe exceptions and normal behavior.
