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Web Engineering

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M1: Introduction

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M1: Introduction to Web Application Development

- Introduction
- Categories of Web Applications
- Web Application Characteristics
- Web Engineering – a new discipline?
- Literature

Introduction

The World Wide Web

- The World Wide Web (WWW) has a massive and permanent influence on our everyday life
- The WWW is omnipresent
- Why?
 - global and permanent availability
 - comfortable and uniform access to often widely distributed information in form of Web pages
 - anyone can consume and publish information

Introduction

Historical Overview (before 1970)

1945

article by Vannevar Bush in "Atlantic Monthly": proposal of a photo-electrical mechanical device called a *Memex* (memory extension) which could make and follow *links* between documents on microfiche

1965

article by Ted Nelson "A File Structure for the Complex, the Changing, and the Indeterminate"
first mention of the term "*Hypertext*"

1968

NLS (oNLine System) by Engelbart
first implementation of a *hypertext system*

1969

ARPANET
the world's first operational packet switching network and the progenitor of the Internet

Introduction

Historical Overview (1970 to 1990)

1974

article "A protocol for Packet Network Interconnection"

introduction of *TCP (Transfer Control Protocol)*

1978

IP (Internet Protocol)

1984

Domain Name System (DNS)

1989

"Information Management: A Proposal" by T. Berners-Lee

"hour of birth of the WWW"

Introduction

Historical Overview (1990s)

1990 *Development of the first command-line browser*

1993 *Release of 1st graphical web browser: Mosaic*

Internet access by dial-up systems (like CompuServ, AOL)

1994 *Foundation of the W3C*

Netscape Navigator 1.0

1999 *XML and RDF become W3C recommendations*

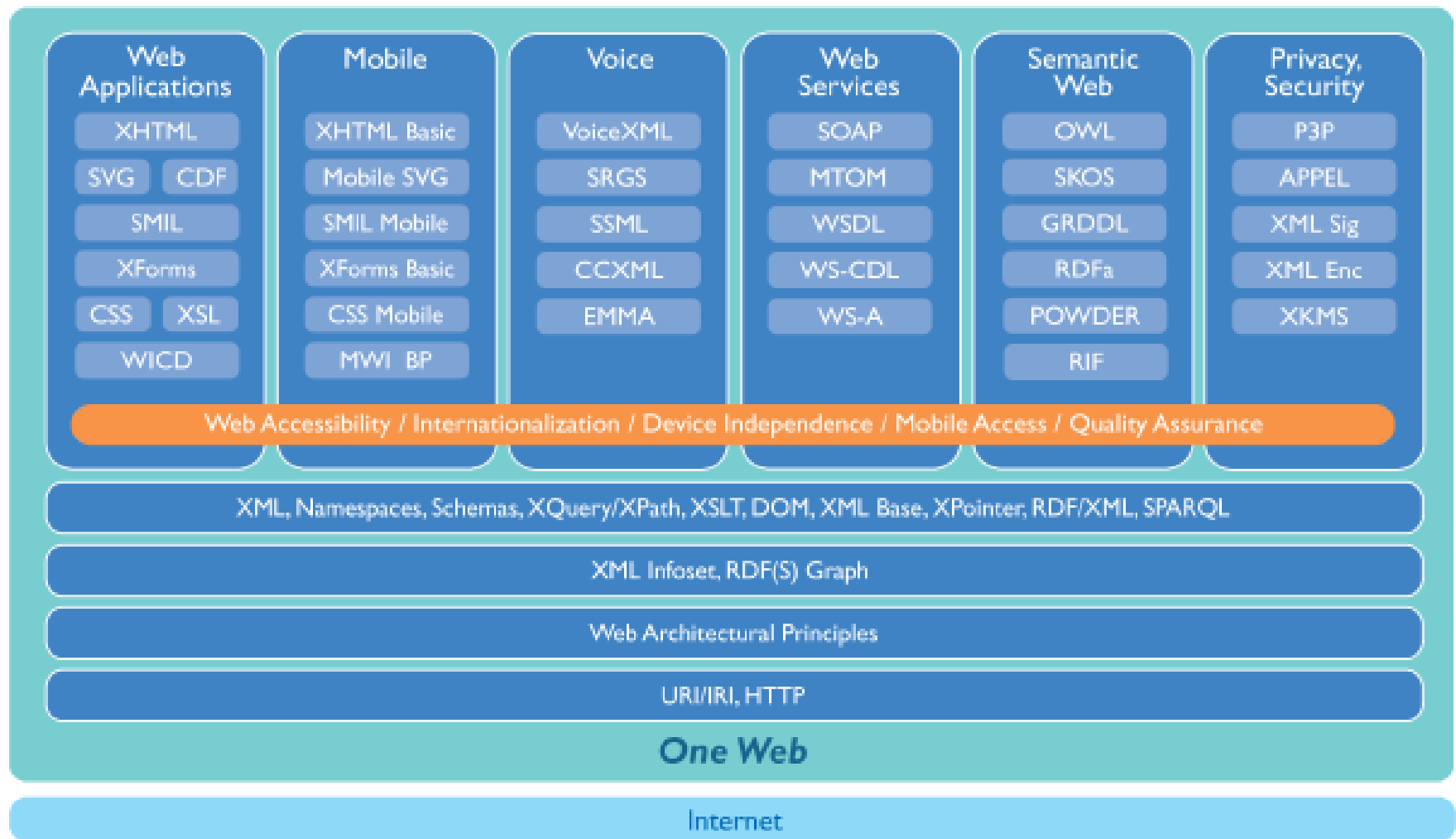
Introduction

The W3C (www.w3.org)

- Consortium to develop standards for the World Wide Web
 - **Mission:** To lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web.
 - **Members:** companies and organisations (but not single persons)
 - Membership fees/3 years contracts
 - Over 400 membership organisations
 - **Reviewing Procedure:** Working Draft → Candidate Recommendation → Proposed Recommendation → Recommendation
 - **Examples** for W3C activities: HTML, XML, CSS, RDF, OWL, ...
 - Other internet standards: Request for Comments (RFC)
-

Introduction

The W3C Technology Stack



Introduction

The Impact of the WWW

- Currently the WWW is among the most important Internet Services.

- It has changed
 - 1. the way people communicate
 - 2. the way business is conducted
 - ⇒ knowledge economy
 - ⇒ knowledge society

- Typical use cases:
 - seeking and using information
 - getting in touch with other people (social networks)
 - reviewing catalogues of online stores
 - ordering products by filling out forms
 - ...

Introduction

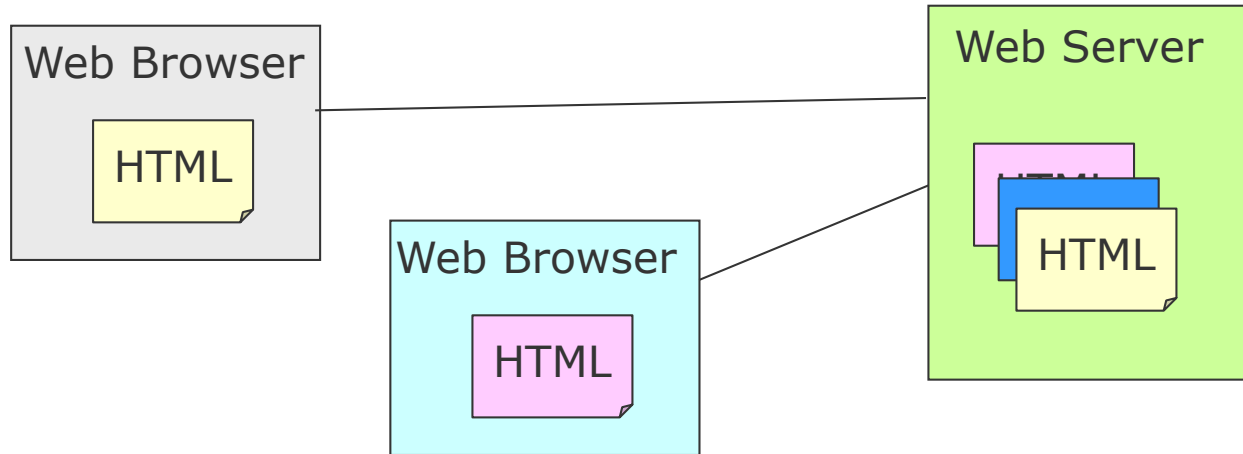
Basic Technologies (1/2)

- **TCP/IP** (Transfer Control Protocol/Internet Protocol): protocols to transfer data via a network
- **HTTP** (Hypertext Transfer Protocol): protocol to transfer information in the WWW – request/response protocol between client and server
- **HTML** (Hypertext Markup Language): language for the creation of web pages which describes how they should be displayed by a web browser
- **XML** (Extensible Markup Language): general purpose markup language for the creation of special markup languages used to facilitate data sharing among different systems

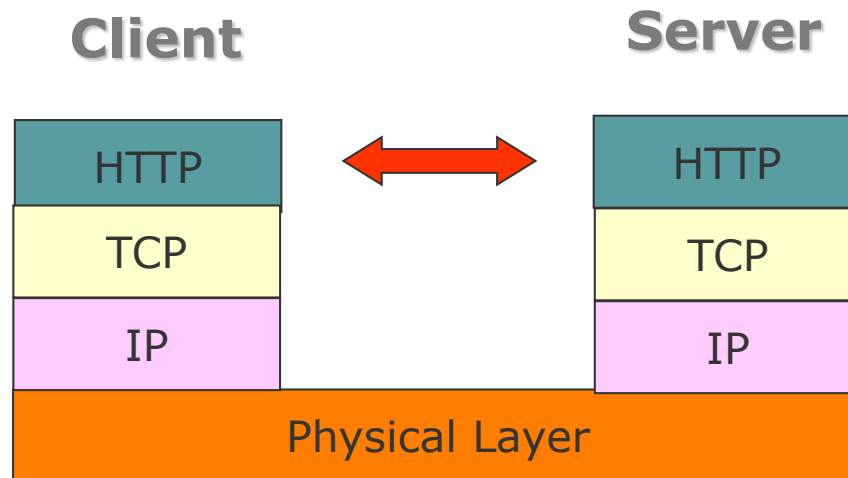
Introduction

Basic Technologies (2/2)

Conceptual client – server architecture



The protocol stack



Web Applications

Definition (1/2)

A Web application is an application that is accessed via the Web over a network

- **Types of Web applications:**
 - presentation-oriented Web applications
 - interactive web pages
 - contain various types of markup languages (HTML, XML, etc.)
 - dynamic content in response to requests
 - service-oriented Web applications
 - endpoint of web services
 - often used by presentation-oriented Web applications

Web Applications

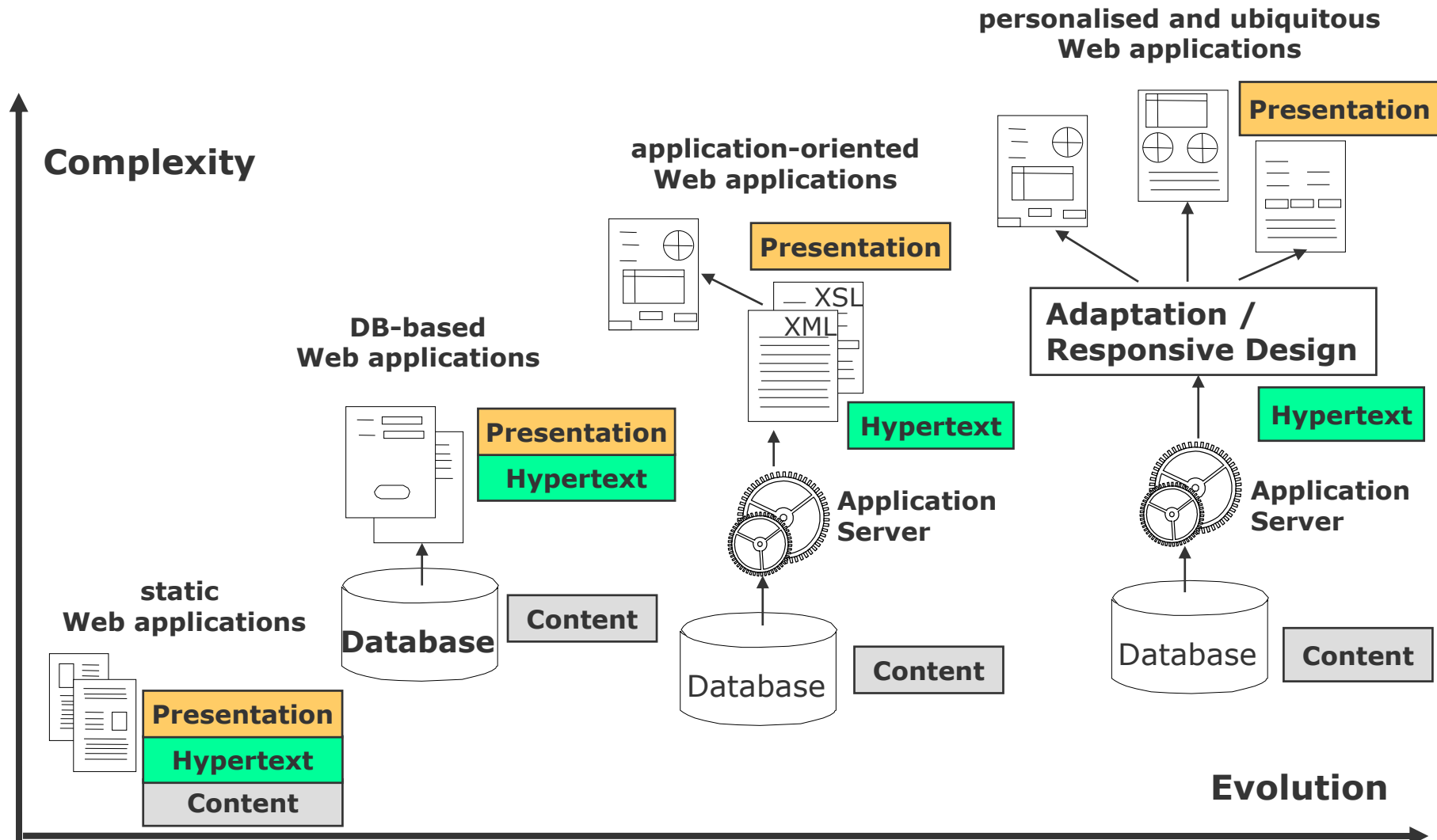
Definition (2/2)

*A web application is a software system based on technologies and standards of the World Wide Web Consortium (W3C) that provides Web specific resources **such as content and services through a user interface, the Web browser.***

- software aspects
 - i.e., static HTML pages are no Web applications
- user interface aspects
 - i.e., technologies alone (like Web services) are also no Web application (but can be part of)

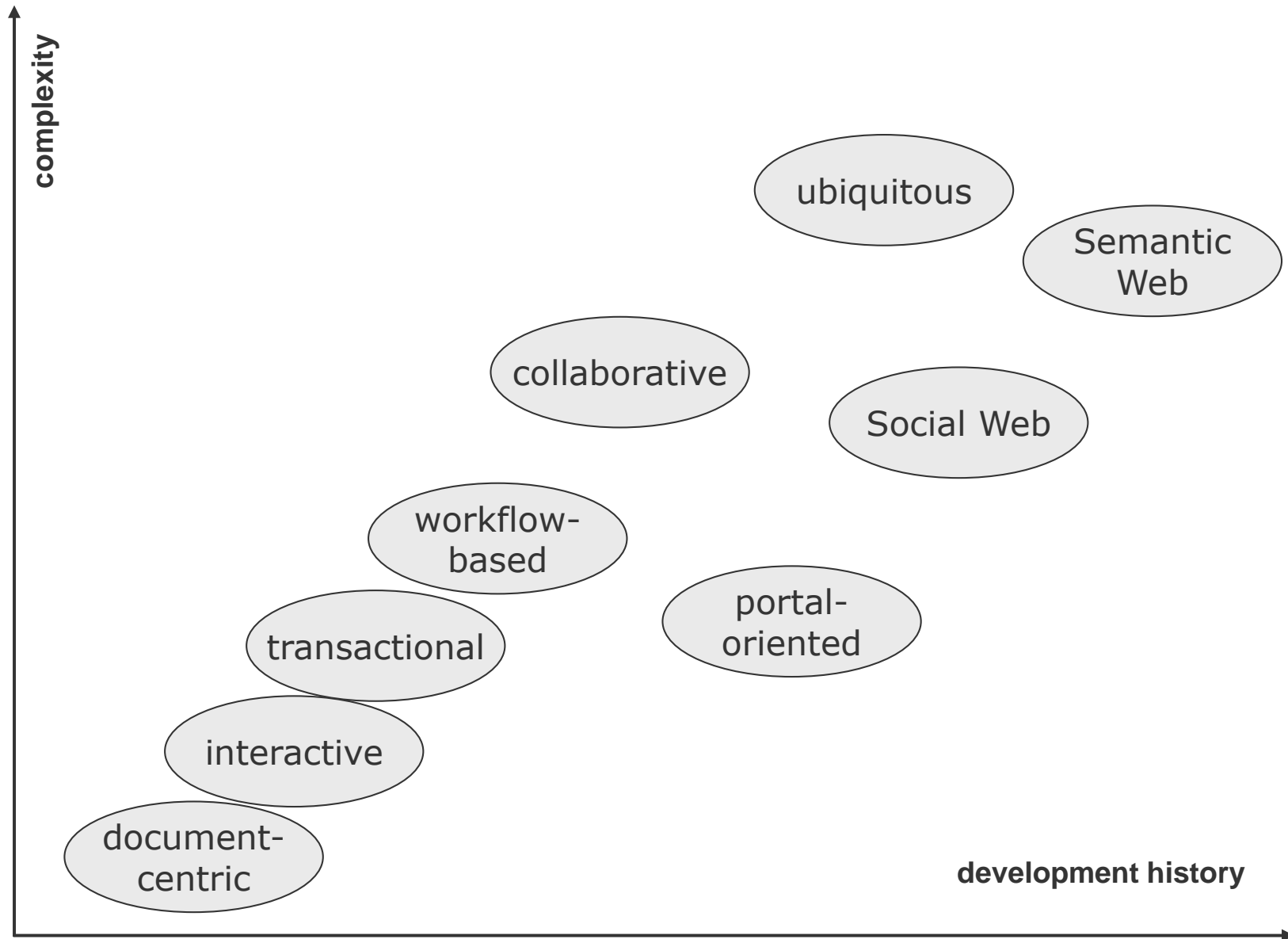
Web Applications

Evolution



Web Applications

Categories (1/2)



Web Applications

Categories (2/2)

- Correlation between chronology of development and complexity
- Development of a Web application can be started in any category and be later expanded to increasing degrees
- Newer categories are generally more complex
 - but this does not necessarily mean that they can fully replace the older generation
 - each category has its specific field of application

Web Applications

Examples of Categories

- Complex Web applications can typically be assigned to several categories at once
 - example: Online shopping malls
 - integration of different service providers
 - offering of several search options
 - order status monitoring
 - online auctions
- Covering of many traditional fields of applications
 - example: Online banking
- Creation of new application domains
 - example: E-Government, E-Learning, ...

Web Applications

Document-Centric Web Sites

- Web pages are stored on a Web server as ready-made, i.e., static HTML documents are sent to the Web client in response to a request
- Updates are usually performed manually
- Examples: static HTML-pages, web casts, small business presentations
- Disadvantages
 - significant cost factor for sites requiring frequent changes/huge number of pages
 - outdated information
 - inconsistencies (multiple storage of the same data)
- Advantages
 - Simplicity and stability of the system
 - Fast response times

Web Applications

Interactive Web Applications

- Content of a website is **dynamically generated** as response to a user
- **Request–form-based input** is the primary mechanism for communication between client and server
- **Common Gateway Interface (CGI) and HTML forms** offered a first kind of interactivity:
 - input areas
 - radio buttons
 - selection menus
- Web pages and links to other pages are dynamically generated according to user input
- Examples:
Virtual exhibits, News-Sites, Public Transportation Information system, ...

Web Applications

Transactional Web Applications

- Highly interactive
 - read and write actions
 - usage of transaction management of database systems
- Use of database systems allow for
 - efficient and consistent data management
 - structured data and queries
- Examples:
 - online banking
 - e-shopping
 - reservation systems

Web Applications

Workflow-Based Web Applications

- Handling of workflows within or between different companies, public authorities, private users, etc.
- Preliminaries:
 - the processes to be automated are well structured
- Challenges:
 - complexity of the services
 - autonomy of the involved companies
 - the business processes have to be robust and flexible
- Examples:
 - Business-to-Business (B2B) Integration Frameworks
 - E-Government
 - patient workflows in health care systems

Web Applications

Collaborative Web Applications

- Cooperation in unstructured operations ("groupware") with highly needs for communication between cooperating partners
- Examples:
 - shared workspaces – common working and information spaces to generate, share and administrate common information in
 - Wiki, <http://c2.com/cgi/wiki>
 - BSCW, <http://bscw.fit.fraunhofer.de>
 - edecision support and meeting mediation, e.g.,
 - arguing systems like QuestMap
 - Chatrooms
 - E-Learning platforms

Web Applications

Portal-oriented Web Applications

- Single point of access to distributed, potentially heterogeneous sources of information
- General portals from
 - browser manufacturers like Microsoft and Netscape
 - search engines like Yahoo
 - online services like AOL
 - media conglomerates and other companies
- Specialised portals
 - business portals:
 - focussed access to different sources of information and services to employees and/or business partners
 - marketplace portals
 - horizontal marketplaces: B2C-area and B2B-area
 - vertical marketplaces: suppliers and manufacturers of a single sector
 - community portals
 - directed at a specific target group
 - try to create loyalty by user interaction
 - individual marketing ("one-to-one marketing")

Web Applications

Ubiquitous Web Applications

- Customized services anytime anywhere and for any device, thus facilitating the ubiquitous access
- Context awareness in terms of
 - Location
 - Time
 - Device, etc.
- Example:
 - displaying the menu of the day on the mobile devices of all users entering a restaurant between 11 am and 2 pm
- Preliminaries:
 - knowledge of the characteristics of the mobile devices
 - context of the Web application

Web Applications

Semantic Web

- Information available on the web
 - adequate for human understanding and
 - adequate for automatic manipulation
- „Knowledge management“
 - derivation of new knowledge
 - re-use of knowledge
 - based on ontologies
- Linking and reuse of knowledge (“Syndication”)
- Locating new relevant knowledge, e.g., by recommender systems

Web Applications

Current Situation

The current situation of Web application development reminds of the software development practices of the 1960s:

- often considered as a one-time event
- ad-hoc development
- based on the knowledge, the experiences and the practices of an individual developer
- reuse by "Copy&Paste" approach
- insufficient and inadequate documentation
- missing methodical approach

Web Applications

Reasons for Deficiencies in Quality

- Document-centric approach
 - Considered to be only an authoring and editorial activity
 - Creation of content, adding images, linking Web pages
- Misconception that Web applications are simple
 - broad availability of different tools (i.e., HTML editors, form generators) permits creation of Web applications without specialized knowledge
 - more emphasis on visual design than on internal structuring
- Know-how from other disciplines cannot be applied
 - Web engineering is different from traditional software engineering (SE)!
 - Nevertheless methods from SE are used without adoption
 - Furthermore, techniques from areas like human-computer interaction are not applied in a consequent manner

Web Applications

Failures in Large-Scale Web Application Development

- Failure to meet business needs (84%)
- Schedule delays (79%)
- Budget overrun (63%)
- Lack of functionality (53%)
- Poor quality of deliverables (52%)

Quelle: Cutter Consortium, *Poor Project Management Number-one Problem of Outsourced E-projects*, Cutter Research Briefs, November, 2000, <http://www.cutter.com/research/2000/crb001107.html>

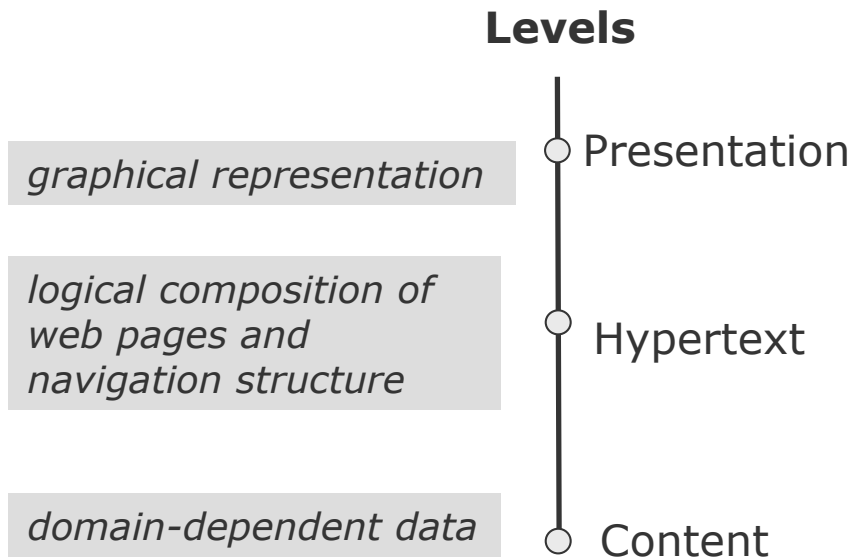
Web Applications

Differences to Software Systems

- What are the differences of general software systems and Web applications?
- Can we use the same techniques to develop Web applications as we are using for developing software systems in general?

**Is Web Engineering the same
as Software Engineering?**

Dimensions of Web Applications (1/3)



■ Separation of Levels

- strict separation of levels
- explicit inter-dependencies between levels

■ Flexible Mapping

- mapping as flexible as possible to allow derivation between levels

■ Bottom-Up and Top-Down Design

- bottom-up: starting with the content level (e.g. given database) and derive the hypertext and presentation level
- top-down: content level is derived from the other levels

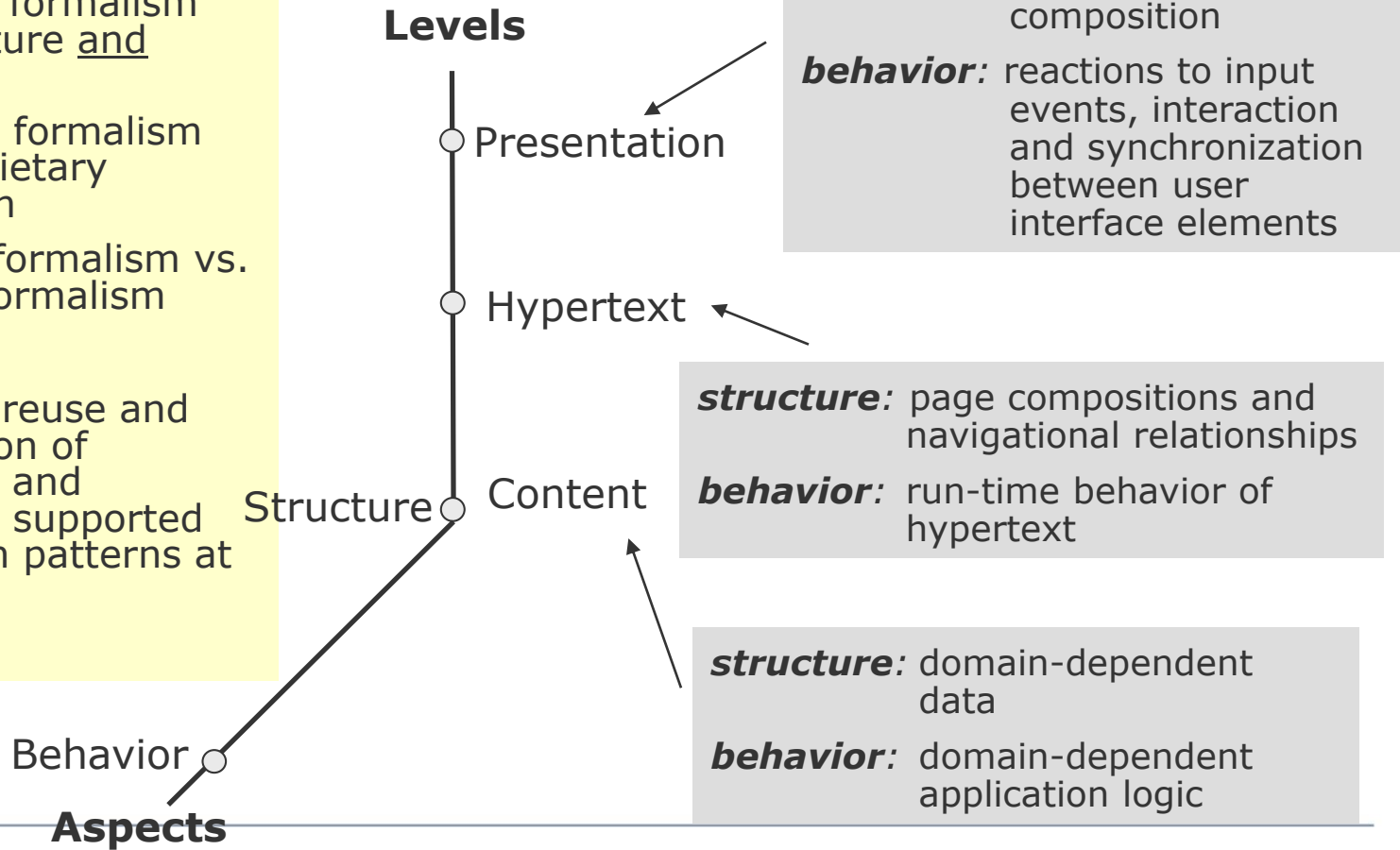
Dimensions of Web Applications (2/3)

■ Formalism

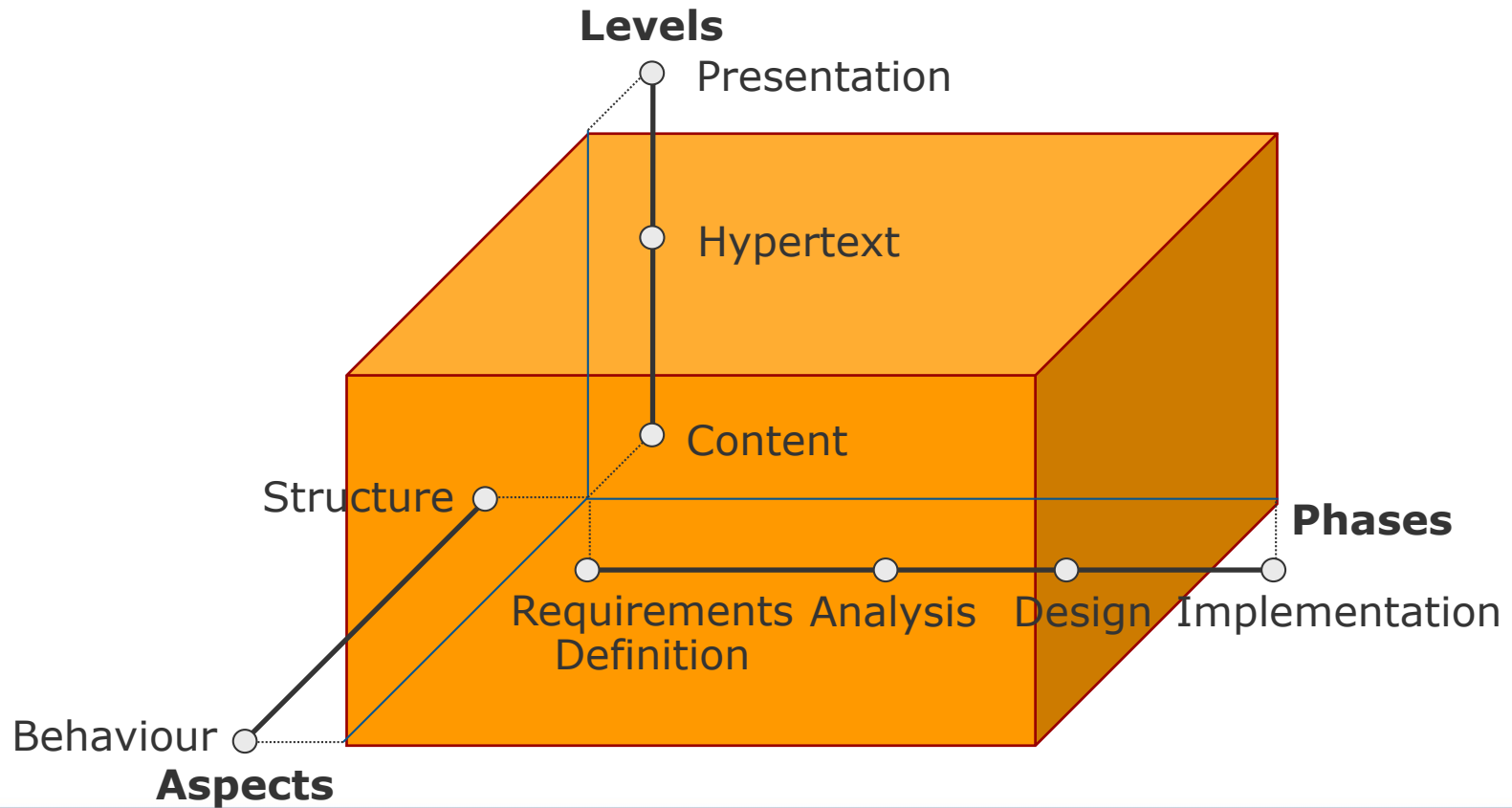
- Modeling formalism for structure and behavior
- Standard formalism vs. proprietary formalism
- Uniform formalism vs. diverse formalism

■ Patterns

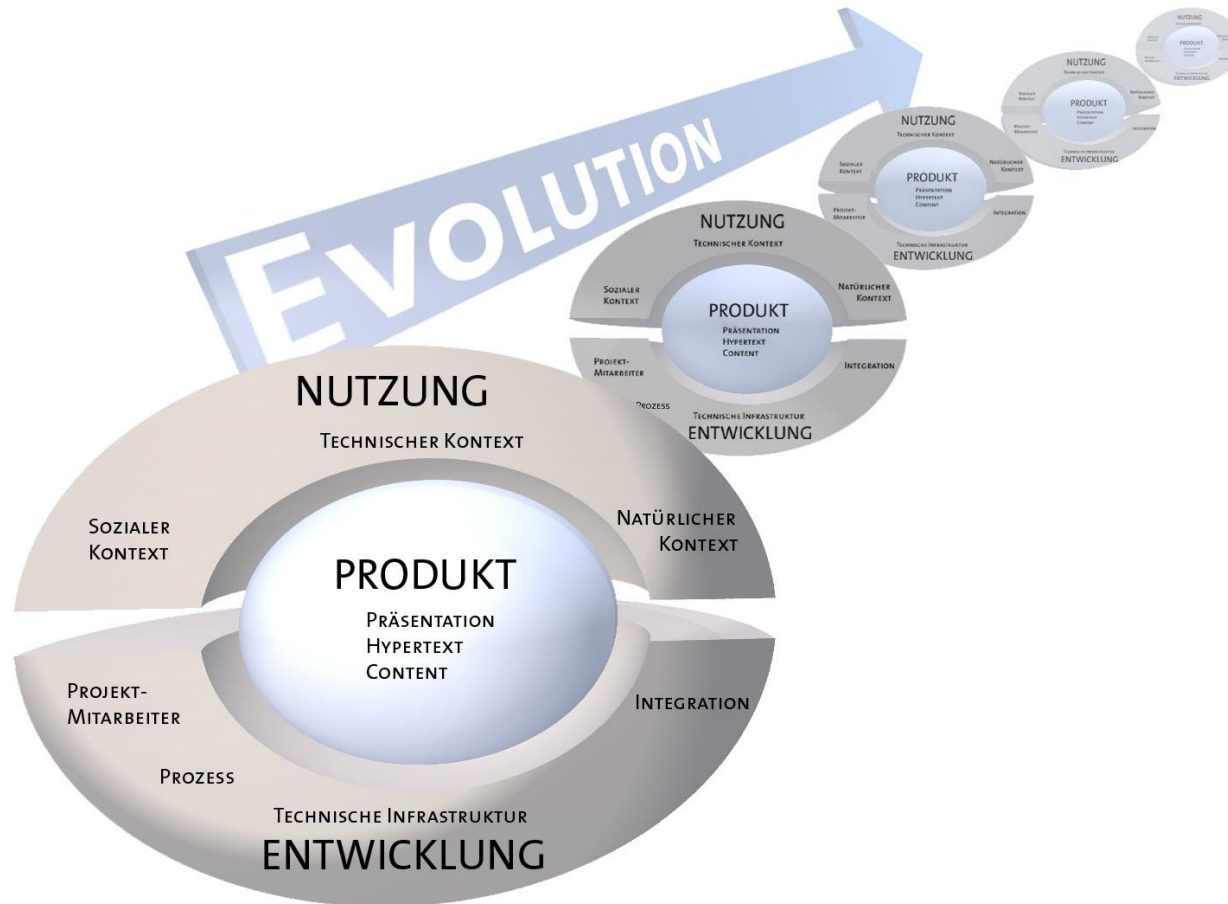
- facilitate reuse and abstraction of structure and behavior, supported by design patterns at all levels



Dimensions of Web Applications (3/3)



ISO Characteristics on Quality Aspects of SW



Characteristics of Web Applications

Product-Related Characteristics (1/3)

■ Content

- document-centric characteristics and multimediality
 - representation with tables, text, graphics, animations, audio, video
 - communication of content is main objective
 - "didactical" presentation of information
 - high usability demands
- quality demands
 - actuality, precision, consistency, trustability and size
 - very important: price and availability information in e-commerce systems
 - critical factor for the acceptance of a Web application

Characteristics of Web Applications

Product-Related Characteristics (2/3)

- Hypertext
 - non-linearity
 - possibility to read systematically ("browsing", "query", "guided tour")
 - move within the information space depending on knowledge and experience of the user
 - special challenge to the author
 - disorientation and cognitive overload
 - disorientation: to lose one's bearings in a non-linear document
 - cognitive overload: additional concentration required to keep in mind several paths or tasks simultaneously

Characteristics of Web Applications

Product-Related Characteristics (3/3)

- Presentation
 - aesthetics
 - "Look and Feel" of the user interface
 - trends
 - self-explanation
 - usage without documentation
 - clear usage

Characteristics of Web Applications

Usage-Related Characteristics (1/3)

- Social Context

- spontaneity

- users come and go ...
 - unknown number of users
 - scalability important issue

- multi-cultural

- anonymous type of user
 - limited knowledge about previous knowledge, handicaps, preferences of users
 - desired adaptation of content and presentation

Characteristics of Web Applications

Usage-Related Characteristics (2/3)

- **Technical Context**

- quality of service
 - unknown network characteristics (e.g., bandwidth, reliability)
- multi-platform delivery / responsive design
 - different types of devices (PC, PDA, mobile phone)
 - different versions of browsers
 - different degrees of functionality, performance, display size, etc.

Characteristics of Web Applications

Usage-Related Characteristics (3/3)

■ Natural Context

- place and time of access
- globalization
 - internationalization of Web applications: regional, cultural, linguistic differences have to be taken into account
 - demands on security: prevent access to private or confidential data
- availability
 - instant delivery mechanism (also in case of partial realizations)
 - permanent (24/7)
 - time-dependent services

Characteristics of Web Applications

Development-Related Characteristics (1/4)

- Project employees
 - multi-disciplinarity
 - mixture of print publishing and software development, marketing and computer science, art and technology
 - IT-experts, hypertext-experts, experts in usability and user-interface design, and domain-experts are necessary
 - Community development
 - publicly available software (incl. source code)

Characteristics of Web Applications

Development-Related Characteristics (2/4)

- Technical infrastructure
 - inhomogeneity
 - two external components
 - Web server
 - Web browser
 - immaturity
 - increasing "Time-to-Market"-pressure
 - continuous evolution of base technology

Characteristics of Web Applications

Development-Related Characteristics (3/4)

- **Process**

- flexibility
 - changing conditions
 - changing requirements
 - changing context
- parallelism
 - parallel development of application (parts)
 - parallel running of the development phases

Characteristics of Web Applications

Development-Related Characteristics (4/4)

- Integration

- **Internal** integration with existing legacy systems
- **External** integration of content and services of external Web services
 - large number of information sources
 - high autonomy of sources with respect to availability and changing of schemata
 - few detailed information about properties
 - heterogeneities within different layers (data, schema, data model layer)

Characteristics of Web Applications

Evolution-Related Characteristics

- continuous change
 - permanent evolution
 - changing requirements and contexts
 - change of characteristics: product, usage, development
- competitive pressure
 - time-to-market
 - necessity of web presence
 - leads to shorter product life cycles
 - leads to shorter development cycles
- fast pace
 - “either you are fast or irrelevant”

Characteristics of Web Applications

Summary

- Web applications have a *multitude of features*
 - which lack traditional applications (e.g., non-linear navigation)
 - which are of particular importance (e.g., frequency of updates)
- Whether a certain characteristic is present depends on the kind of Web application, for example:
 - transactional Web applications like e-commerce systems require greater focus on the content being up to date and consistent compared to a pure information provisioning system
- These characteristics are the reason why many concepts, methods, techniques, and tools of traditional software engineering
 - have to be adapted
 - may be inadequate

Web Engineering

Definition

- (1) Web Engineering is the application of systematic and quantifiable approaches (concepts, methods, techniques, tools) to cost-effective requirements analysis, design, implementation, testing, operation, and maintenance of high-quality Web-based systems and applications.
- (2) Web Engineering is also the scientific discipline concerned with the study of these approaches.

**Web Engineering
is a specialisation of
Software Engineering.**

Web Engineering

Basic Principles of Web Engineering

- Clearly defined goals and requirements
- Systematic development of a Web application in phases
- Careful planning of these phases
- Continuous audit of the entire development process

Literature

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