

Quality of Experience – aware Adaptive E-Learning Environments

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Overview

- **Research profile**
- **Research directions and projects in e-learning**
 - Learner QoE based adaptive and personalised e-learning
 - Cost/We-Learn - Cost-efficient selection and delivery of e-learning content
- **Another project that involves user QoE**
 - iPersonal IPTV - Interactive Personalised IPTV for entertainment
 - Can be easily transformed into multimedia-based TV-learning
- **Summary of the talk**

Research Profile

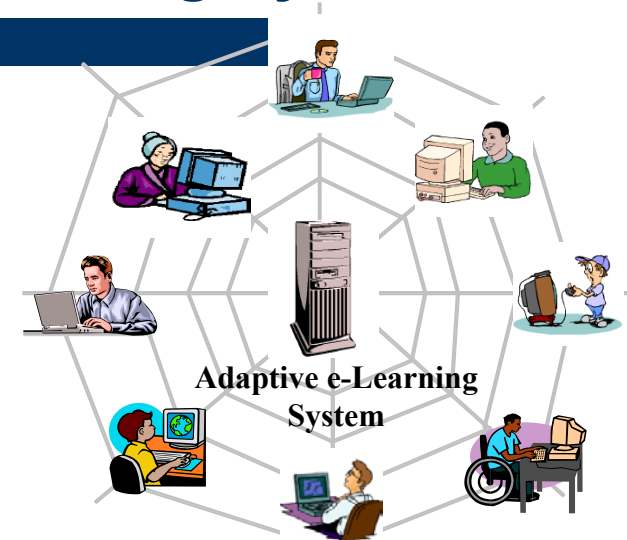
- **Ph.D. degree from Dublin City University (2005) - Ireland for research on end-user Quality of Experience with adaptive hypermedia systems**
 - Exemplification in the area of personalised and adaptive e-learning
- **6 years Researcher with Dublin City University**
- **Lecturer with National College of Ireland (NCI) since 2006**
- **My research interests**
 - Performance-aware cost-efficient adaptive e-learning systems
 - User Quality of Experience
 - E-learning over wired/wireless networks using various devices
 - Personalised IPTV
- **Achievements**
 - Over 25 peer-reviewed publications in int. journals & conferences + 1 book
 - 1 Best Paper and 1 Second Best Paper awards at top international conferences
 - TPC member/reviewer for international journals and conferences

Adaptive E-Learning

- **Status**
 - e-Learning is increasingly used in education and corporate training
 - E-Learners are interested in getting personalised rich media content
 - Mobile and wireless solutions enable content delivery anywhere & anytime
- **Issues**
 - Different user expectations related to content, performance delivery & cost
 - Large diversity of devices have different requirements/constraints
 - Rich media content is expensive to produce and has associated a price
 - Various network environments affecting content delivery
- **Research projects that address these issues**
 - User QoE Layer for adaptive and personalised e-learning systems
 - Cost/We-Learn - Cost-efficient selection and transmission of e-learning content

A) User QoE Layer for Adaptive E-learning Systems

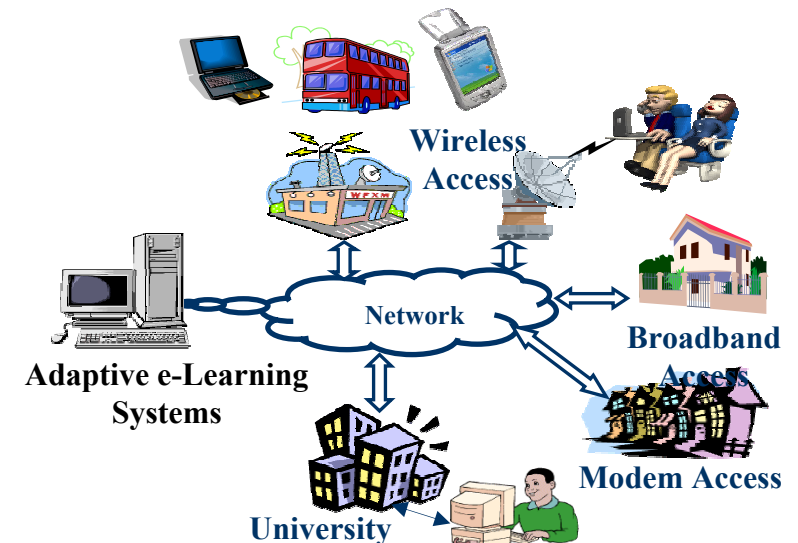
- **Adaptive Educational Hypermedia (AEH)**
 - Provides *personalised content and navigation support* to suit the learners' individual characteristics
 - Adaptation based on the user profile (knowledge, goals, special needs) and/or learning styles



... a solution that improves user experience...

But not enough ...

- **New communication technologies**
 - Offer *"anytime and anywhere"* access to information *from diverse devices*
 - *Network environments* have widely varying performance characteristics



A) User QoE Layer for Adaptive E-learning Systems



Aim of the Project

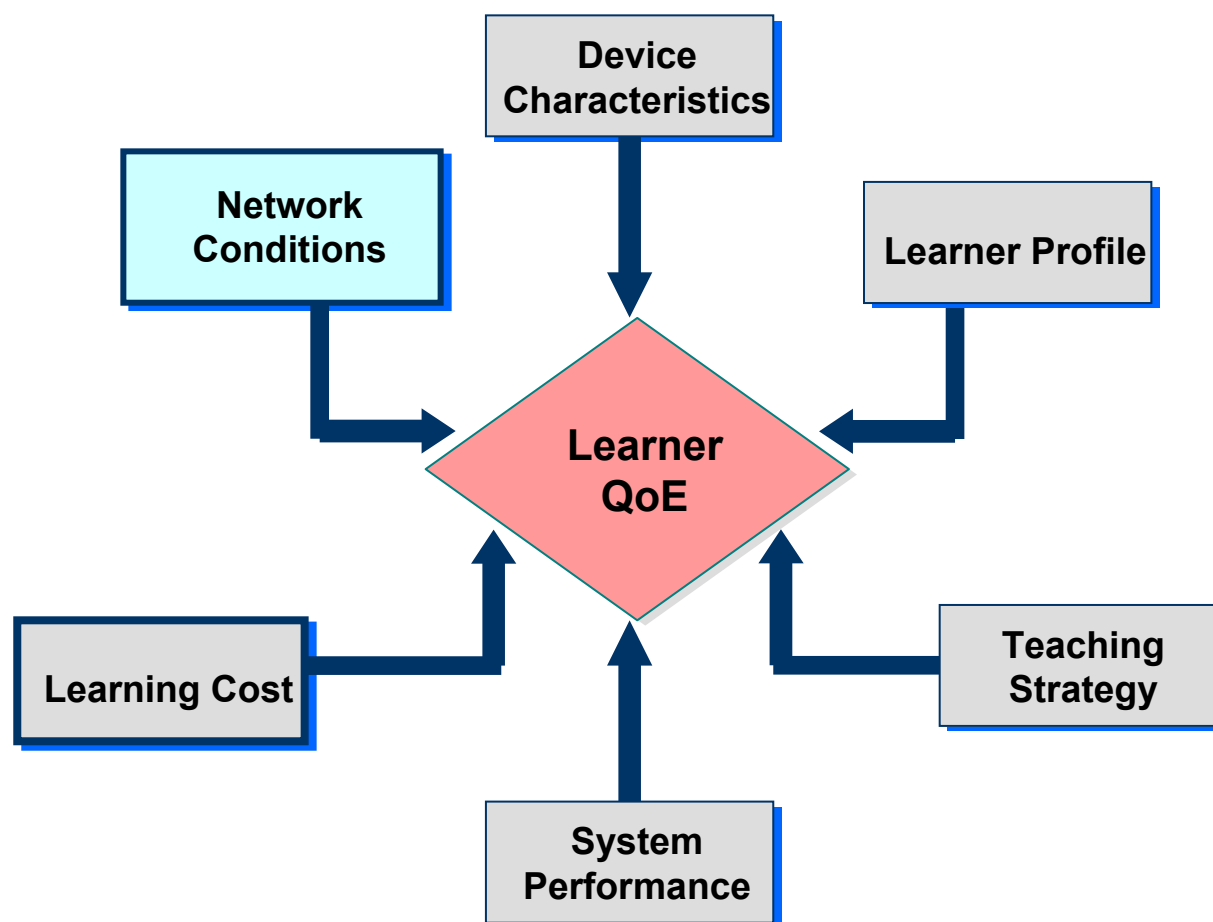
- Explores another dimension of individual differences between learners: learner QoE with the on-line educational system
- Analyses what affects learner's QoE
- Maximises QoE when people access personalised content via various and changeable operational environments
- Proposes an adaptive e-learning solution based on
 - user personal characteristics (e.g. skills, goals)
 - user experience with the service (e.g. performance, user behaviour)

A) User QoE Layer for Adaptive E-learning Systems

What is Quality of Experience?

- **QoE focuses on the end-user**
 - *“a collection of all the perception elements of the network and system performance relative to users expectations” **
- **QoE concept applies to any kind of network-based interaction**
 - e.g. Web navigation, multimedia streaming, voice over IP
- **ITU-T R. G1010**
 - Guidance on key factors that influence QoE
- **QoE also known in other areas**
 - **Business:** Subjective measure of a customer’s experiences with a vendor. Analyses a vendor’s offering from the customer point of view
 - **Medicine:** Subjective measure of a patient’s experiences with a medical practice. Looks at a care provider’s offering from the patient’s experience point of view

A) User QoE Layer for Adaptive E-learning Systems



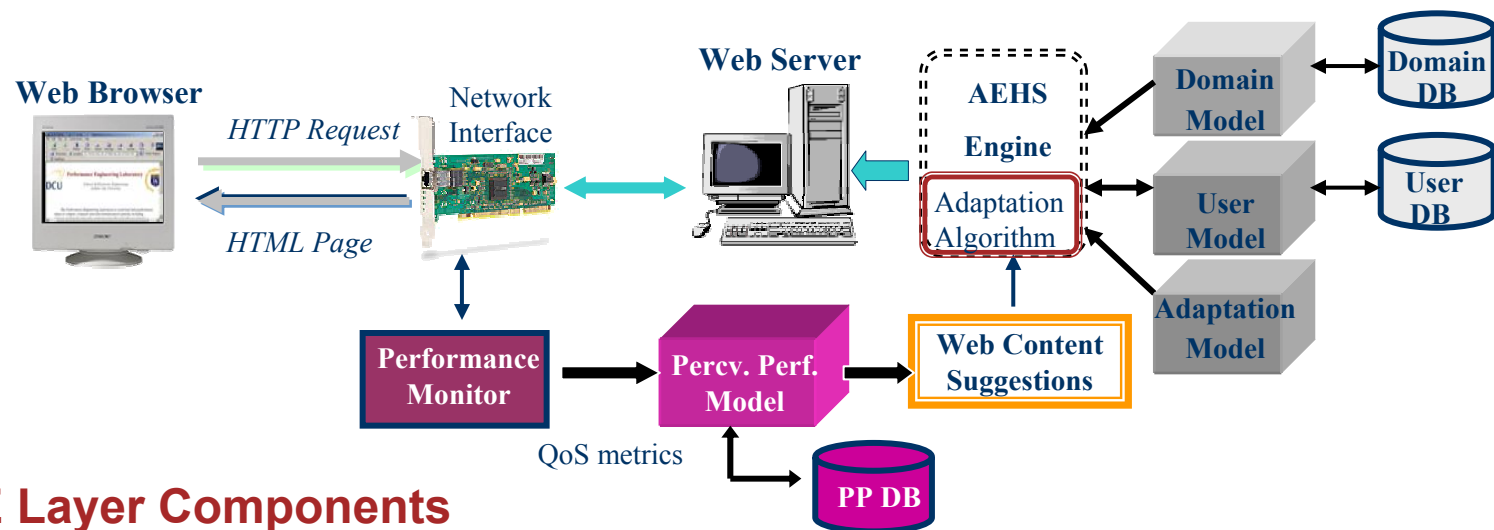
A) User QoE Layer for Adaptive E-learning Systems



QoE Layer

- **Enhances AEHS' functionality with a new QoE-based content adaptation strategy**
- **Measures & analyses different metrics that factor into the user QoE**
 - Download time, round-trip time, perceived download speed
 - User tolerance for delay, temporal variation of user satisfaction
- **Content adaptation based on both:**
 - *user profile* (skills, knowledge, goals, learning style, etc.)
 - *current delivery conditions* that may affect the learner QoE
- **Outcome: User QoE-aware AEHS**
 - QoE Layer + AHA! system

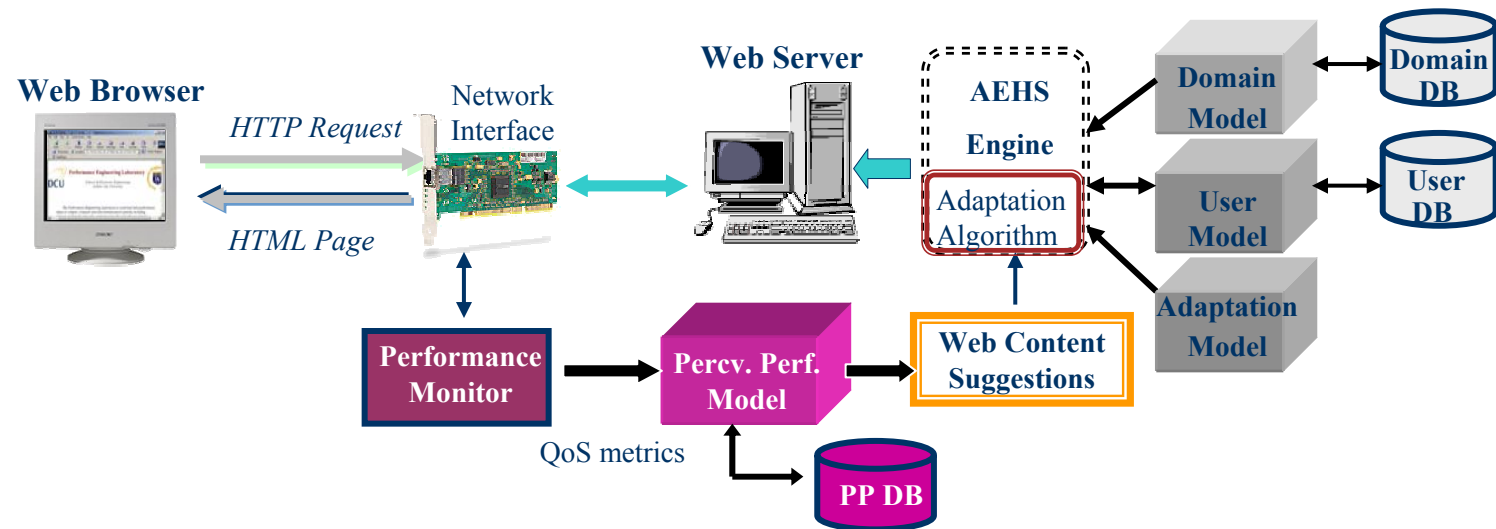
A) User QoE Layer for Adaptive E-learning Systems



QoE Layer Components

- **Performance Monitor**
 - Measures metrics that reflect QoE and user behaviour
- **Perceived Performance Model (PPM)**
 - Stereotype based modeling of user QoE related to network delivery conditions
 - Provides suggestions on the optimal characteristics of the content
 - Number of embedded objects, Size of the embedded images, multimedia properties
- **Adaptation Algorithm**
 - Content adaptation strategy for matching PPM suggestions

A) User QoE Layer for Adaptive E-learning Systems



AEHS Engine

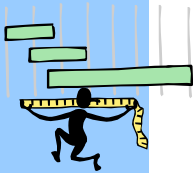
Stage One: Classic user-tailored AM-based adaptation

- interprets condition-action rules from AM
- performs content selection
- creates navigational support (links)

Stage Two: User QoE-based adaptation

- dynamically adjusts selected content
- adaptation based on PPM suggestions

A) User QoE Layer for Adaptive E-learning Systems



Assessment of the QoE Layer

- **Type of Web content considered: Images + text**
- **Simulation tests: investigate user perceived performance improvements**
 - Constant & variable low bit-rate operational environment (28 -128 kbps)
 - Comparison with non-adaptive transmission (no QoE)
- **Subjective tests in the educational area**
 - Deployment on the open-source AHA! system => QoEAHA system
 - The comparison-based experimental study: AHA! vs QoEAHA
 - This study assessed:
 - Learning capabilities (learning outcome & learning performance)
 - Learning Usability & user QoE
 - Visual Quality

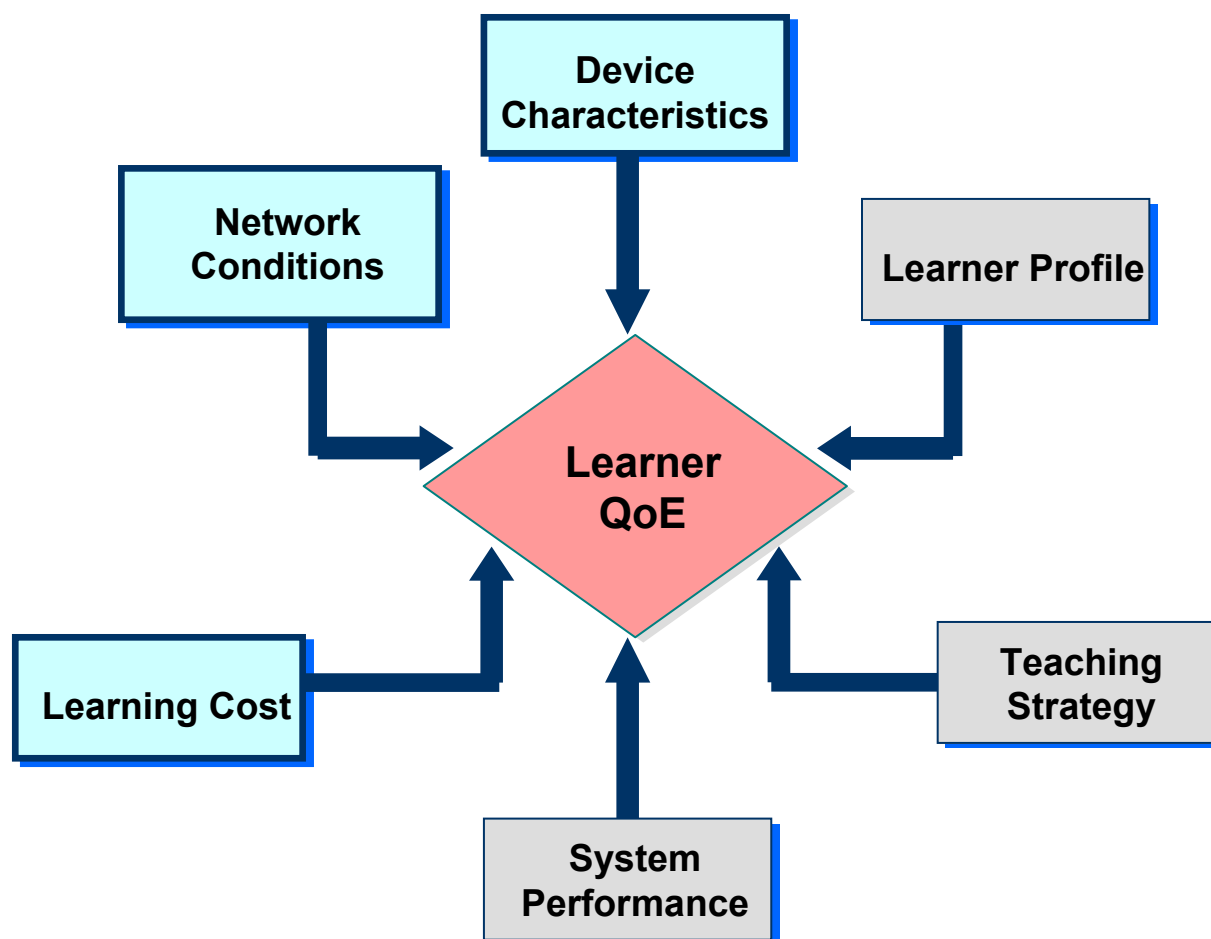
A) User QoE Layer for Adaptive E-learning Systems

Conclusion of the Tests



- **PPM Model learns quickly about delivery conditions**
- **PPM suggestions make sure that access time is always maintained at acceptable level (<15 sec)**
- **QoE Layer brings benefits in the educational area when e-learners have a heterogeneous operational environment.**
 - Learning performance improvement in terms of:
 - Execution of a learning task (16.27%)
 - Access time per page (12-15 sec)
 - Number of revisits to a page (65% of students required only one visit)
 - Overall usability improvement (7.5%)
 - Increased user QoE (17.8%)
 - QoE Layer does not affect student learning outcome

Elements that factor into Learner QoE



Ultimate goal: provide good Quality of Experience to e-learners

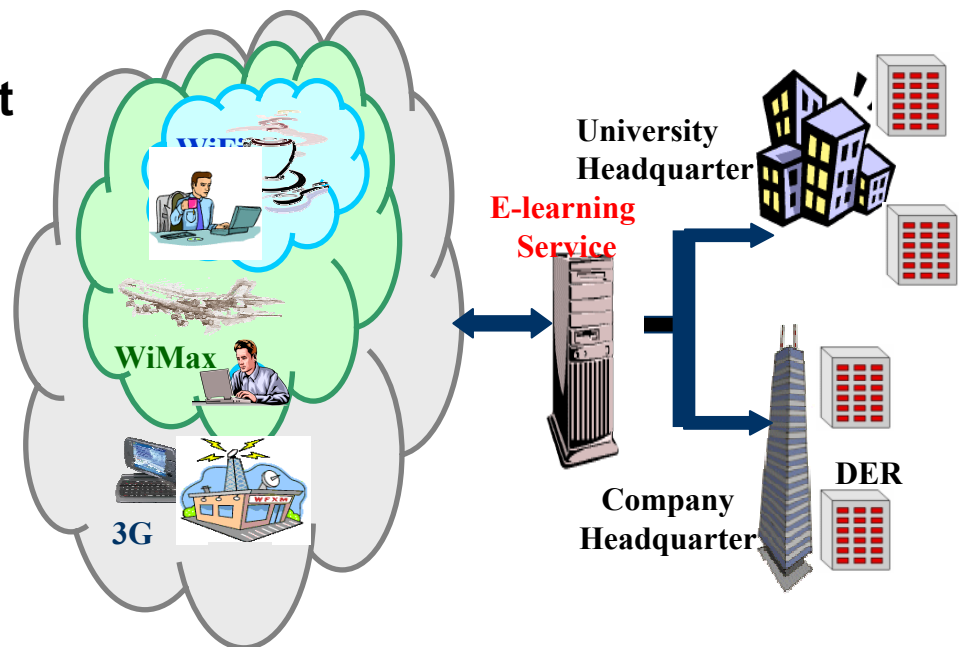
B) Cost/We-Learn



GOAL: Supports intelligent selection and distribution of personalised educational material offered by third party providers to wireless devices

IDEA

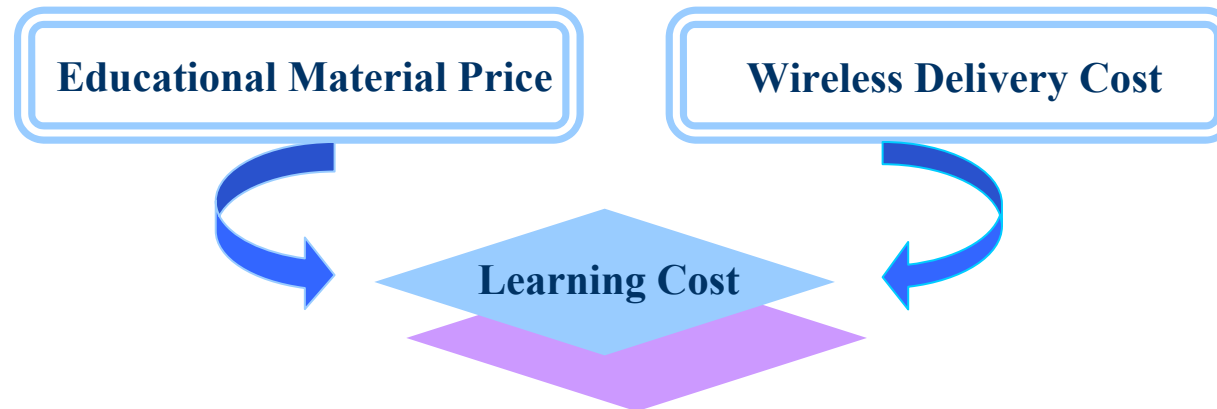
- A mobile device may offer Internet connectivity via multiple wireless technologies
 - e.g. WiFi, Bluetooth and WiMax
- Wireless networks have different:
 - performance characteristics (bandwidth, mobility support, congestion level)
 - **billing** policies



Each learner has a budget limit for online learning !



B) Cost/We-Learn



- **Educational Material Price:**

- The amount of money paid for having the right to access the desired educational material (e.g. course registration fee, monthly fee or pay per document)

- **Wireless Delivery Cost:**

- Data transfer cost required by an Internet wireless provider/distributor (e.g. price/KB, price/sec, monthly fee)

B) Cost/We-Learn

Achitecture

- **DER (Digital Educational Repositories)**

- store Learning Objects (LOs) that belong to learning content providers

- **Cost-efficient Learning Management System (CLMS)**

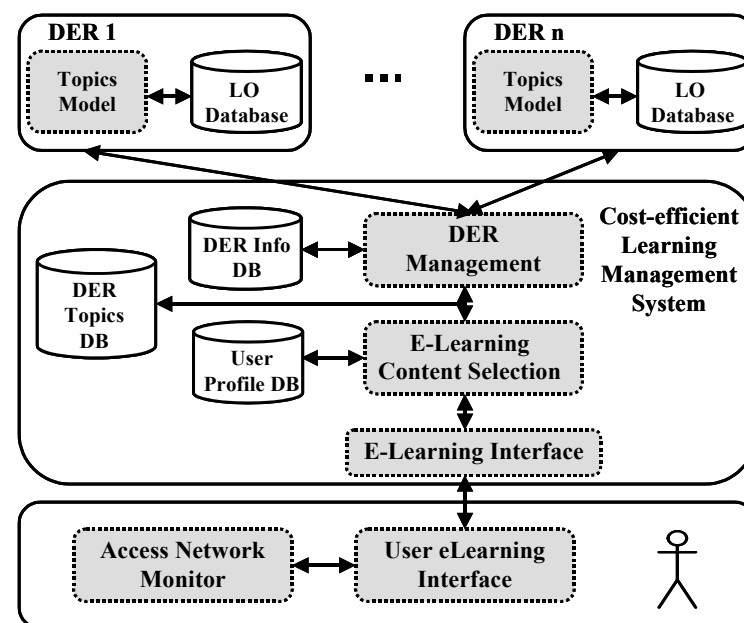
- implements the cost-efficient personalised content selection and distribution algorithms

- **Client Application includes:**

- E-Learning Interface
- Network Monitor watches for the availability of all wireless networks on the device.

- **Intelligent cost-efficient selection and distribution of personalised educational material based on**

- User goal & Budget constraints
- Device characteristics & Wireless connection characteristics



B) Cost/We-Learn

What are the benefits?

- **Meeting place between e-learning companies/organisations and learners**
 - Learners that are looking for educational content that matches their learning goals, budget limitations, connectivity characteristics and device capabilities.
- **E-learning companies may increase their revenue by advertising low cost self-contained contents that may be part of a more complex course provided at a higher price**
- **For the e-learners**
 - flexibility to pay only for the information received and not for the entire course
 - choice of using that wireless network which best responds to their needs in terms of the download cost and delivery performance

C) iPersonal IPTV - Framework for Interactive Personalised IPTV for Entertainment

Introductory Information (IPTV)

- Mass migration from analog to digital TV and lately to interactive TV (iTV)
- iTV: viewers interact with an application that provides different services
- Sustained increase in residential broadband IP network connectivity
 - a low-cost high-bandwidth infrastructure
 - enables the distribution of services that use IP-based applications
 - Services: Shopping, e-Learning, TV
- **The future is: IP-iTV - a multimedia IP-based application**
 - Magnet Network (Ireland), Microsoft (IPTV), Novamedia (Iceland), Fastweb (Italy) are already offering IPTV services

IPTV widespread success highly depends on both the cost of the service and the viewers' Quality of Experience (QoE).

C) iPersonal IPTV

Need for Personalised IPTV

- **Various devices have diverse characteristics**
 - PDA, laptops, LCD-TV, HD-TV sets
- **Different networking solutions**
 - Wireless or wired networks
 - various delivery rates & load levels
- **Viewers are different**
 - have to choose between hundreds of programs
 - have different characteristics, interests, goals, etc.
 - have different quality expectations

iPersonal IPTV Project

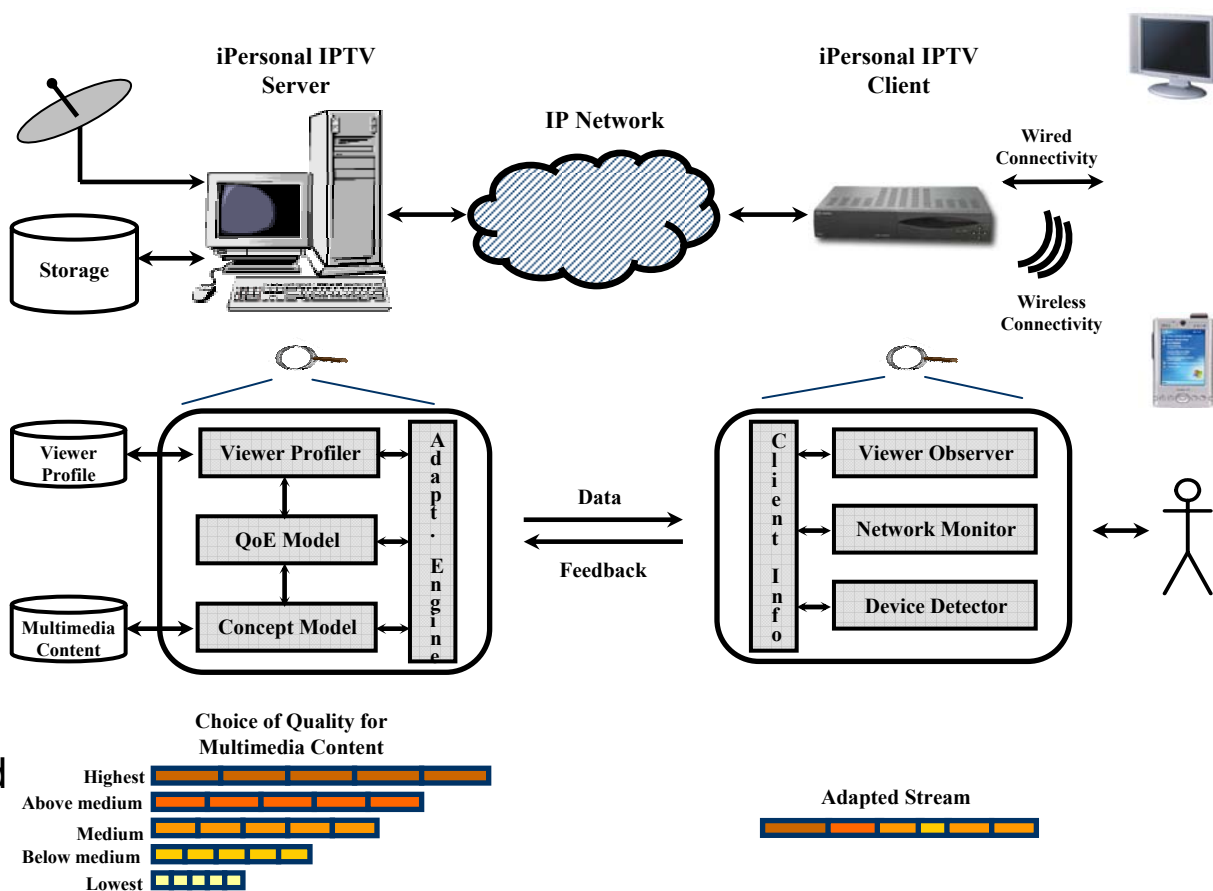
Research collaboration between NCI and PEL@DCU

C) iPersonal IPTV

GOAL: Personalise and adapt multimedia-based TV content to:

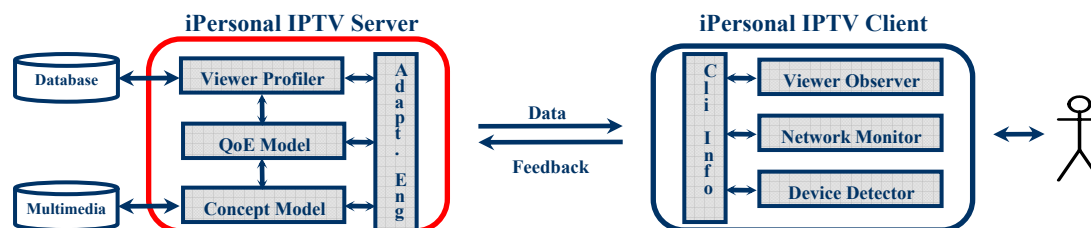
- Viewers interests
- Network conditions
- Device

- Uses quality-based automatic feedback
- Maintains high end-user perceived quality (QoE)
- Allows for differentiated treatment per user
- Can be applied in TV-based learning



C) iPersonal IPTV

iPersonal IPTV Server



- **Concept Model (CM)**

- A four level hierarchy of multimedia content (e.g. movies, shows, news, etc.)
- A set of concepts among which logical relationships exist
- Different types of concepts:
 - Abstract concept (e.g. news cast or movies)
 - Topic (e.g. RTE News)
 - Atomic concept / item (e.g. whether section RTE News cast)
 - Versions (a multimedia clip that has certain formatting characteristics)

- **Viewer Profiler (VP)**

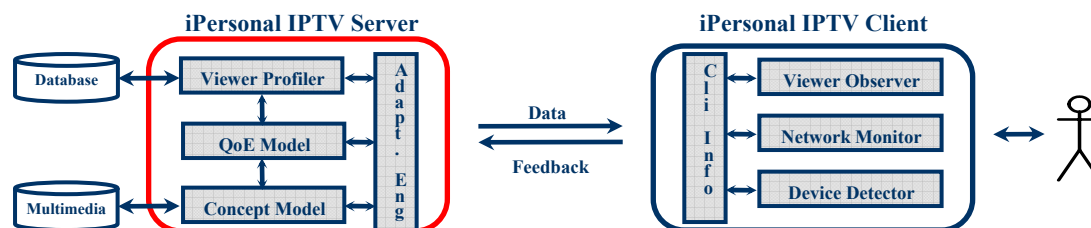
- maintains user-related data: demographic info interests, device type, connection type...

- **QoE Model (QoEM) suggests**

- multimedia items selection based on VM
- Multimedia adaptation during streaming process

C) iPersonal IPTV

iPersonal IPTV Server

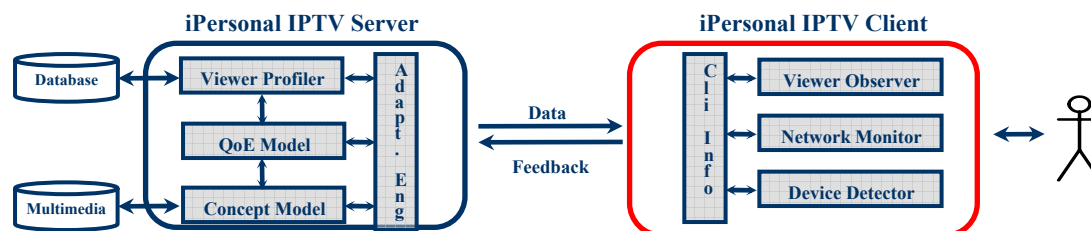


- **Adaptation Engine (AE)**

- Performs multimedia content adaptation in a two-step process:
- **Coarse Grained Adaptation (Personalisation)**
 - *choose the content that suites to user interests, device and network conditions*
 - *=> certain multimedia version is selected for delivery*
- **Fine Grained Adaptation (Adaptive Streaming)**
 - *performed dynamically during the streaming process of selected multimedia item*
 - *multimedia content quality is varied to suit the delivery conditions*
 - *content adaptation is based on feedback received from the iPersonal IPTV Client*

C) iPersonal IPTV

iPersonal IPTV Client



- **Viewer Observer (VO)**
 - Acquires data for the Viewer Profiler initialisation.
 - Monitors the viewer's behavior (e.g. content selection, play, abort) and updates VP
- **Device Detector (DD)**
 - detects the characteristics of the device used
- **Network Monitor (NM)**
 - observes network performance-related parameters (e.g. delay, jitter and loss)
 - describes the status of the transmission medium
- **Client Feedback Info Unit (CF)**
 - receives reports from: Viewer Observer, Network Monitor and Device Detector
 - computes feedback grades and regularly sends it to the server

C) iPersonal IPTV

Benefits

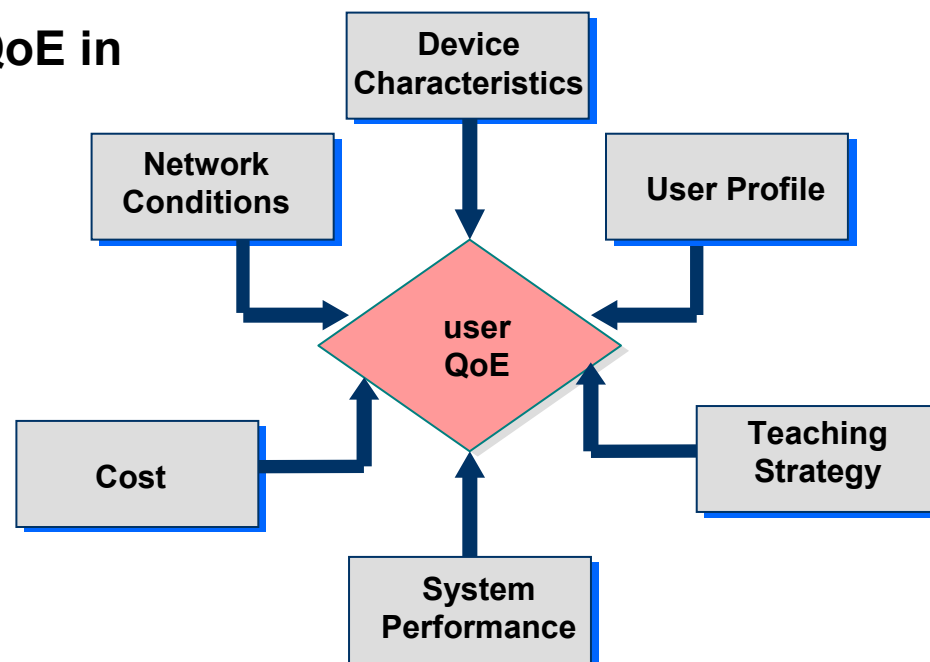
This solution is of interest to:

- **IPTV Service providers and network operators**
 - it will allow them to deliver personalised content in the right form
 - increasing the number of happy viewers
 - attracting new viewers, increasing their subscriber base
 - increase their revenue

- **Viewers**
 - it will enable distribution of content tailored to their interests, delivery network and devices,
 - increasing their quality of experience with the provided service

Summary of the Talk...

- **What is (learner) QoE ? Key elements that may affect QoE**
 - Network connectivity, device, person's profile, cost, teaching strategy (e-learning)
- **2 research projects that address QoE in the area of e-learning**
 - QoE Layer for AEHS => QoEAHA e-learning system
 - Cost/We-Learn
- **Another research project that investigates user QoE in IPTV**
 - iPersonallPTV



Questions ...

