

*Research Seminar, University of Prishtina*

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*New Generation of Smart e-Learning  
Systems and BigData Analytics*

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*28<sup>th</sup> December 2020*

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# Agenda of this talk

## ▶ **PART I: E-LEARNING SYSTEMS—CURRENT STATE**

- 1 **Disruptive Technologies for e-Learning**
- 2 **BigData e-Learning Analytics**
- 3 **A3 Paradigm: Anywhere, Anytime, Awareness**

## ▶ **PART II: NEW GENERATION OF E-LEARNING SYSTEMS —THE ROAD AHEAD**

- 1 **Emotion-Aware e-Learning Systems**
- 2 **Trustworthy e-Learning and e-Assessment**

## ▶ **CONCLUSIONS & OUTLOOK**



## Part I

# e-Learning Systems—Current State



# e-Learning/Collaborative Work: A Global Phenomenon

▶ **As a follower of distant learning, E-LEARNING HAS THE INTERNET AGE!**

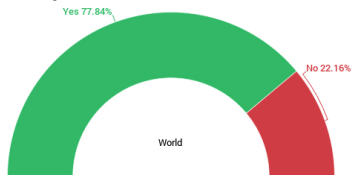
▶ **PLACE AND TIME SHIFT** – **study** and **collaborate** anytime and anywhere!

▶ World Economic Forum: **Online learning is the future of education**

▶ Covid-19 Pandemics: **Online Collaborative Work is the future of remote working and collaboration**

▶ 77.84% people from across the world reported having taken online courses in the past.

Have you ever taken an online course?



e-Learning Market: estimated to \$255 billion by 2017. ▶

# The Shift from Web-based Learning

▶ **E-LEARNING HAS THE INTERNET AGE!** However, **several paradigms have passed through:**

- **Web-based centric/static e-Learning**
- **Grid-based e-Learning**
- **Service-oriented e-Learning**
- **P2P-based e-Learning**



# The Shift from Web-based Learning

- ▶ **Web, Grid and P2P e-Learning systems very fast evolved to:**
  - **e-Learning Portals** and **Virtual Campuses**
  - To meet **demanding requirements from online learners/teachers**
  - To **scale to thousands of online learners**
  - Due to evolution of concepts of: **discussing, sharing, collaborating, personalisation,...**etc.
  - Thanks to evolution of an array of technologies:
    - ▶ **Cloud Computing**
    - ▶ **Social Networking**
    - ▶ **Mobile and Ubiquitous Computing, etc.**



# e-Learning Convergence with Mainstream Technologies

## ▶ TWO PARADIGMATIC EXAMPLES

▶ Currently in the **mainstream of e-Learning systems**:

▶ **BigData e-Learning Analytics**

▶ **Mobile e-Learning: A3 Paradigm –Anyware, Anytime, Awareness**



# e-Learning BigData from Online Virtual Campuses

- ▶ Learning Management Systems are producing a massive amount of data (BigData) related to:
  - interaction among students; among student and the LMS
    - ▶ **interaction data**
  - accomplishments of the students
    - ▶ **academic performance data**
  - activity behaviours of the student
    - ▶ **behavioural/profile data**
- ▶ **BigData e-Learning analytics:** support actors in the LMS (students, teachers, managers and stakeholders) with meaningful reports.
- ▶ **Monitor activity and progress of the e-learning processes**





# BigData from Online Virtual Campuses (cont'd)

- ▶ **BigData e-Learning analytics:** Three views
  - The **snapshot view**: provides a snapshot of the current state of the learning process.
    - ▶ Interesting to spot issues *on the fly* for real-time re-action.
    - ▶ Requires BigData Stream processing (real-time results).
  - The **historical view**: provides a broader picture of the learning process during a certain period of time
    - ▶ Requires BigData processing (offline results).
    - ▶ Enables to see teaching/learning effects
  - The **predictive view**: provides expected results and actions of the learning process
    - ▶ Uses past information to predict future outcomes
    - ▶ Requires BigData processing and Artificial Intelligence (esp. **Neural Networks**).



# BigData Predictive Model

## ► What can be predicted?

- Prediction on the student's success
- Prediction on competence/skill acquisition
- Prediction on drop-out within a course
- Prediction on retention in the program or educational organization
- Prediction on student's satisfaction

## How?

- Classification
- Clustering
- NN, Supervised Learning, Unsupervised Learning, ...



# Log data files from Online Virtual Campuses

- ▶ **Real Log Data files** from the online activity of students in the Virtual Campus of the **Open University of Catalonia (Barcelona, Spain)**
- ▶ Open University of Catalonia (Spain):
  - Large Virtual Campus –about **50,000 online users** (students, lectures and tutors from everywhere)
  - 30 official degrees and other PhD and post-graduate programs resulting in more than 600 official courses.
  - **The campus is completely virtualized.**
  - It is made up of individual and community areas (e.g. personal electronic mailbox, virtual classrooms, digital library, on-line bars, virtual administration offices, etc.).



# Data Sources of of Virtual Campus

- ▶ Large log files are recorded from different LMS systems:
  - 1 Main **Virtual Campus** Server Logs
  - 2 Learning Management Systems such as **Moodle**...
- ▶ **Log files of about 20-25 Gb daily... and *growing!***



# Log data files from Online Virtual Campuses (cont'd)

- ▶ Recording such **user-user and user-system interaction data**, usually in the form of log data files, could be very useful for different purposes:
- **user modelling** (personalization, context, navigation patterns, resource access and usage,...)
  - **user activity analysis** (classification, activity patterns, ...)
  - **security, trustworthy, monitoring**, etc.
  - data analytics (**learning analytics**, system usage analytics, **academic performance analytics**, etc.)

# BigData eLearning Analytics: The Processing Cycle

## The Cycle:

- ▶ Gathering
- ▶ Pre-processing / Cleaning
- ▶ Storing
- ▶ Analyzing/**Mining, Machine Learning**
- ▶ Visualizing
- ▶ **Security, quality, governance are cross-cutting features!**

## The challenge:

- ▶ ***How to process Big Data using the current state-of-the-art technology?***
- ▶ ***Under time and budget constraints!***
- ▶ ***At long run!***

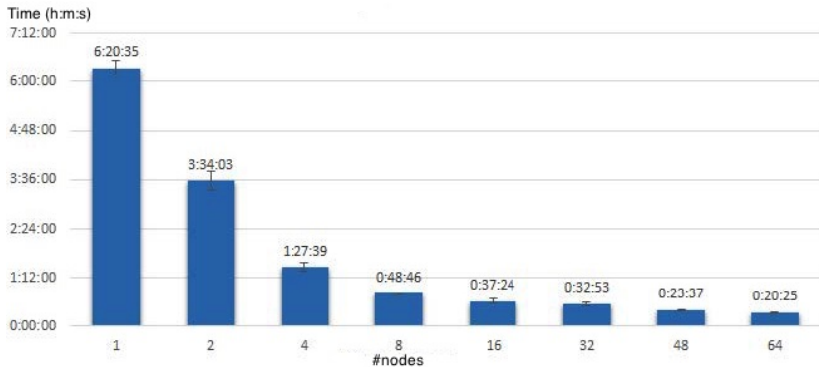
# The Big Data size becomes an issue...

- ▶ **Hadoop, Spark, Flink, ...** + HDFS, YARN, MapReduce etc.
- ▶ **RDLab HPC infrastructure** at BarcelonaTECH:
  - Over 160 physical servers.
  - Over **1000 CPU cores** and more than **3 TBytes of RAM** memory.
  - Over **130 TBytes of disk space**.
  - High speed network at 10Gbit.
- ▶ And also Cloud environment of the **Amazon Web Services**—EMR (Elastic MapReduce) Service with a Spark cluster.



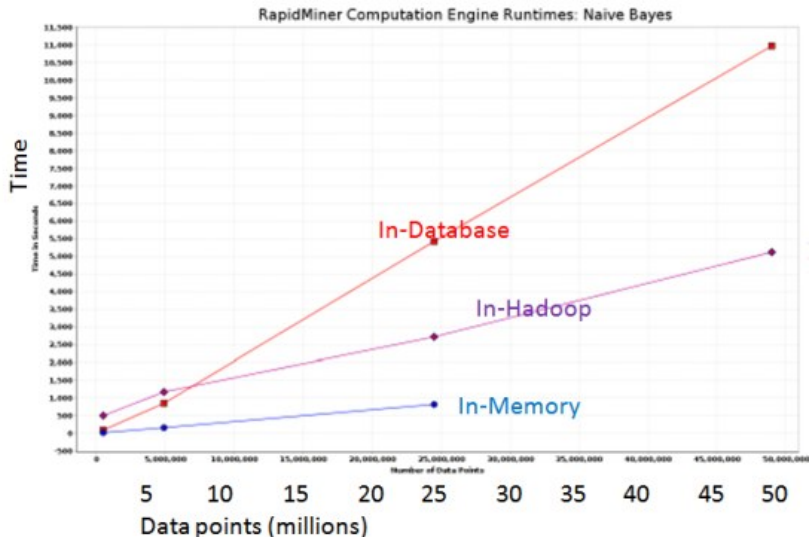
# Supporting Online/Offline e-Learning Analytics

- ▶ Hadoop time for e-Learning Analytics from 32GB data set.





# Memory choices: In-memory-in-Hadoop-in-Database



# A3 Paradigm: Anytime, Anywhere, Awareness

- ▶ **Mobile collaborative applications:**
  - **Geographical Distribution and Mobility**
    - ▶ To support team members' mobility.
    - ▶ Cannot assume continuous network connectivity.
    - ▶ **CAP THEOREM** –Brewer's theorem– Consistency, Availability, Partition tolerance.
    - ▶ Mobile collaborative work: online and offline mode.
  - **Awareness Services**
    - ▶ Be informed on the actions of other team members.
    - ▶ Context awareness of resources, of members, workspaces, project workflow, etc.
    - ▶ **Application migration** among user's devices (**WebRTC**-based application migration)



# Context-Awareness: Sharing Online Collab. Activity

## ▶ **Event-Condition-Action (ECA) Rules:**

### **Event Notification Services**

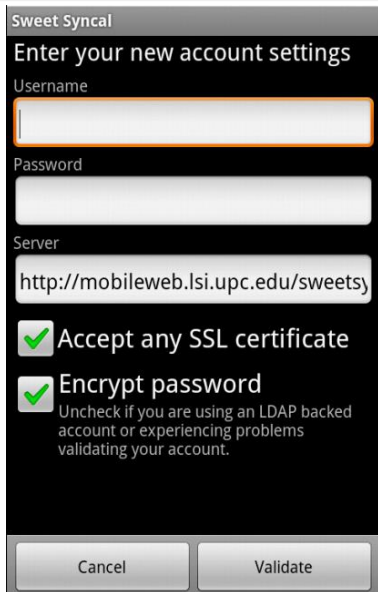
▶ Project state (documents, files, workplan, messages, discussions, and calendar.

▶ **Group project calendar:** pending tasks, organize online meetings, online discussions, **qualified voting**, etc.

▶ Allow users to create and modify their own calendars that contain events and tasks.

▶ Users can share tasks and events with other users

▶ Users can participate in several calendars



Sweet Syncal

Enter your new account settings

Username

Password

Server

Accept any SSL certificate

Encrypt password  
Uncheck if you are using an LDAP backed account or experiencing problems validating your account.

Cancel Validate

# Implementation and Technologies

- ▶ **Android** –Mobile Clients.
- ▶ **Android-Binding** –External open source library (greater independence between the view and system –MVVM pattern.)
- ▶ **SugarCRM** – Application server (real setting).
- ▶ **Memcached** –Storing cached data or objects, thus reducing the need to access an external data source.
- ▶ **JXTA / WebRTC** –P2P open source platforms.
- ▶ **PeerDroid** – JXME for the Android platform. It allows to create applications for the Android platform using JXTA properties.

## Part II

# New Generation of e-Learning Systems –The Road Ahead

# Upcoming Trends in e-Learning Systems

- 1 ▶ **Emotion Awareness and Feedback in e-Learning**
- 2 ▶ **Trustworthy e-Learning**
- 3 ▶ **Multi-modal Interaction Applications (gesture interaction, voice recognition, eye gaze, facial expression, etc.)**
- 4 ▶ **Augmented Virtual Reality & Conversational Agents**



# Emotion Awareness and Feedback in e-Learning

- ▶ **Emotional experiences** influence student's motivation, learning strategies and achievement
- ▶ **Student's emotional states** are influenced by a variety of factors (personality, virtual classroom characteristics, ...)
- ▶ People are able to express a wide range of emotions, which vary in intensity, duration, context, etc., during activity time

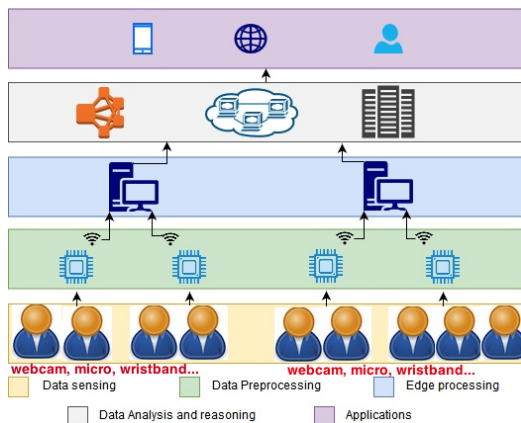
## Emotional Awareness:

- ▶ *An **emotion classification model** to detect emotions in educational discourse in a non-intrusive way;*
- ▶ *Making **emotion awareness** explicit both at individual and at group level*



# IoT-based Emotion Model

- ▶ **Label and classify students' emotional states:**
- ▶ **IoT-SENSORED COLLECTED DATA** in a virtual learning environment.
- ▶ **Provide feedback** to students & keep them in a loop!
- ▶ **EDGE COMPUTING**
- ▶ **"ANOMALY" DETECTION ALGORITHMS** (e.g. HTM –Hierarchical Temporal Memory)
- ▶ **Emotional Climate of Virtual Classrooms**





# Trustworthy e-Learning

▶ **Trustworthiness** is a level of the subjective probability with which an agent [A] assesses another agent [AA] (or group of agents / service).

▶ **Trust / trustworthiness** is becoming central to new LMS systems:

- Is the content in virtual rooms trustworthy?
- Is the learning experience reliable and credible?
- Do students trust their peers?
- How does trust evolve over time during learning experiences?
- How does trust affect learning outcomes and grades?



# Trustworthy e-Assessment Model (cont'd)

At the end of each collaborative stage, each student had to complete a **survey**.

Valoració de cada membre del teu grup de treball durant el curs

Per a cada un dels companys de grup i tenint en compte que les respostes han d'estar basades en el treball en grup que has desenvolupat durant el curs, valora a cada company en l'escala de 1 (poc) a 5 (molt). A la columna "P" selecciona el teu codi de grup. Segueix aquest procediment per les 5 preguntes següents (P1 - P5):

PREGUNTA 1: La informació transmesa per Mx, ha estat clara, transparent i honesta. \*

	0 (poc)	1 (poc)	2	3	4	5 (molt)
M1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
M2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
M3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
M4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Google Forms

The coordinator of the group complete two **reports**, public and private.



## INFORME DEL COORDINADOR SOBRE LA VALORACIÓ DEL GRUP

Nom i cognoms del coordinador de la fase (Nom i Cognoms):

Nom del grup de treball:

Data de l'informe:

4/18/2013

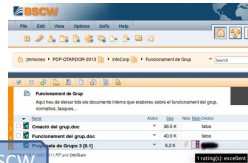
Hem d'ingressar el diferent estat d'opinió grupal. Després hem de descarregar el document "Documents per al consultor" del vostre grup en el BSCW. Passarà el nom "Informe@nomGrup@nomFase.doc".

1. Com valoreu el treball realitzat com a grup i el funcionament del grup en els següents aspectes:

- a) Les aportacions equitàries per part dels membres del grup al llarg de la fase actual han estat:  0 a 10: 5

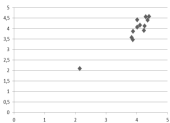
Doc

BSCW



**Rating systems.**  
General LMS indicators.

Similarity

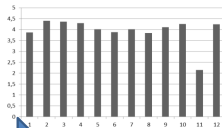


Google Forms

Normalized / preprocessed data  
A typical daily log file size, up to 20 GB.  
After this preprocessing, 2.0 GB of potentially useful information



Trustworthiness Levels



3. Trustworthiness Assessment and Prediction

# Conclusions

## ▶ **E-LEARNING AND ONLINE COLLABORATION HAVE THE INTERNET AGE!** –PROJECTED AS THE FUTURE OF EDUCATION AND COLLABORATIVE WORK!

- **Millions of people** worldwide taking online courses and working online.
  - **Billions of \$** of worth economic value
  - **Virtual Campuses and Open Universities** (Open University of Catalonia –largest online university in Spain!)
- ▶ A shift from web, Grid, P2P-based LMS to **A NEW GENERATION OF LMS** based on **Cloud, Big Data, Mobile computing, Social Networking** technologies:
- Big data e-Learning Analytics
  - Social Networking
  - A3 Paradigm: Anytime, Anywhere, Awareness



# Outlook: Re-thinking, Re-implementing, Re-architecting, ...

▶ New generation of LMS is being driven by **convergence** and **technology integration**:

- 1 Emotion Awareness and Emotional Climate of Virtual Classrooms
- 2 Trustworthy e-Learning
- 3 Multi-modal Interaction Applications
- 4 Augmented Virtual Reality and Conversational Agents







▶ To achieve:

**Placing learners at the center**: adopt to the learners' way, to personalized learning paths, just-in-time learning-as-a-service!

**MAXIMISE LEARNING OUTCOME AND EXPERIENCES AT SCALE**



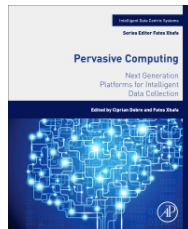
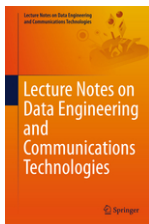
# Some references...

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  -  Arijit Nandi, Fatos Xhafa, Laia Subirats, Santi Fort: A Survey on Multimodal Data Stream Mining for e-Learner's Emotion Recognition. **COINS 2020**
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  -  Arguedas, M., Xhafa, F., Daradoumis, Th., Casillas, L., Peña, A., Caballé, S.: A model for providing emotion awareness and feedback using fuzzy logic in online learning. **Soft Computing** (2016). <https://doi.org/10.1007/s00500-016-2399-0>
- ▶ **[WEB]** <http://www.informatik.uni-trier.de/~ley/pers/hd/x/Xhafa:Fatos.html>

# Interested to publish in International Book Series?

## ▶ **Lecture Notes in Data Engineering and Communication Technologies, Springer.**

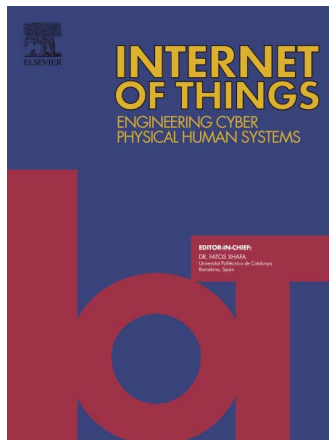
<http://www.springer.com/series/15362>



## ▶ **Intelligent Data Centric Systems, Elsevier**

<https://www.elsevier.com/books/book-series/intelligent-data-centric-systems-sensor-collected-intelligence>

► **Internet of Things; Engineering Cyber Physical Human Systems.** <https://www.journals.elsevier.com/internet-of-things>





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Q?

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