WEB-BASED ENERGY INFORMATION SYSTEM FOR OPTIMAL BI-DIRECTIONAL BEHAVIOURAL CONTROL OF VARIOUS ENERGY CUSTOMERS USING ADSL HYPERUBIC CLUSTERING AND INTERNET SERVICES

(EMIR System)

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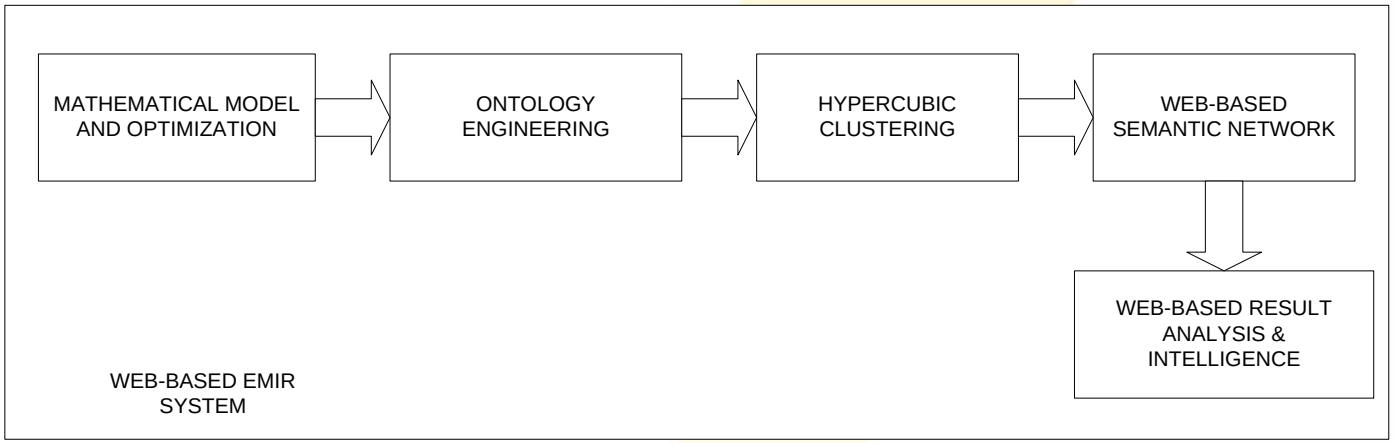
The Research Idea

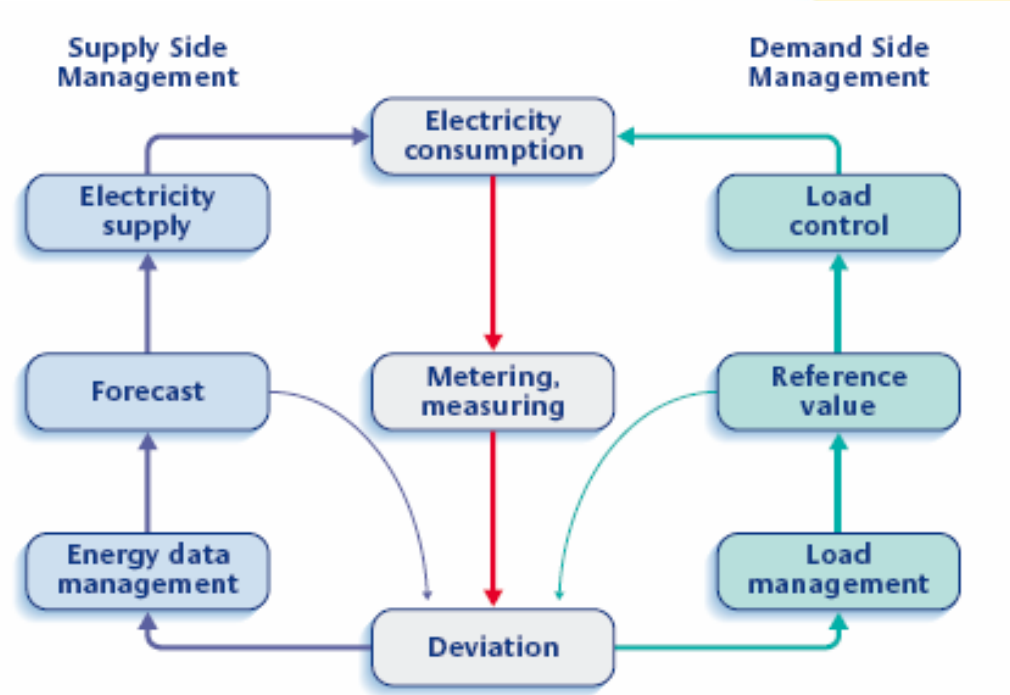
- Multidimensional Energy Knowledge Management
- ADSL-based measurement techniques
- Data processing through Internet portal
- On-line peak load management
- Energy and Cost minimization
- Energy Scorecards and KPI management
- Web Broker in on-line Energy Stock-Market
- …everything through ADSL and Internet…
- …strong mathematical background for EKM
- …differential topology is a nice solution for optical reasoning
- …effective use of Data Fusion philosophy

Energy Knowledge Management (EKM)

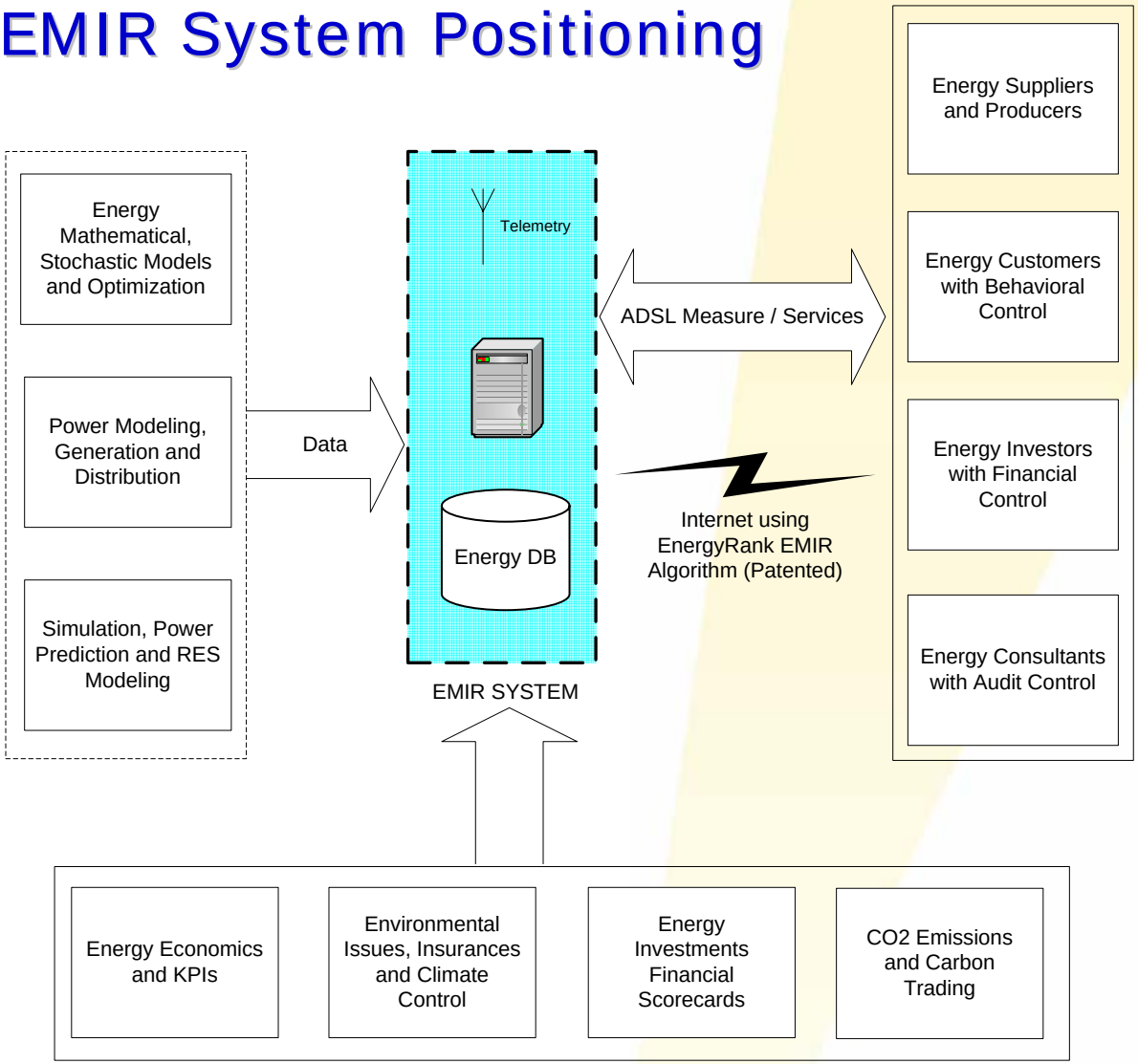
- Real-time Energy management through ADSL pools
- Dynamic Pricing and personalized Energy Services
- A complete web-based Strategic Energy DSS system
- Integrated Energy Information System (EIS) for ESCOs
- Embedded Energy KPIs and dynamic Scorecards
- **EMIR System**: Energy Management & Intelligent Reporting



EMIR System in a closed feedback loop



EMIR System Positioning



Energy base Mathematical Model

The typical load vector **L**D, comprised of various daily load vectors **μ**m can be described as

$$L_D = \mu_m^L + \sum_{i=1}^{j} w_d^{Li} v_m^{Li}$$

where **μ**m and **v**m are deterministic parameters and **w**d is a daily stochastic process.

$$\sum_{j=1}^{n} \left(Q_j - L_\Delta - L_E \right) * SMP + \sum_{i=1}^{m} \left(Q_i^a - L_i^a \right) * SMP = 0$$

Energy Balance Equation is shown above

Functional Attributes

Load Elasticity	Demand to be completely inelastic (i.e. independent of market clearing price)
Load Seasonality	Seasonality is a major driver for electricity demand observing seasonality over the daily, weekly, and yearly cycles
Load Mean Reversion	Temporary spikes in electricity demand, often induced by extreme weather conditions. However, these spikes are not sustainable and demand reverts back to normal levels within a few days, hours
Stochastic Growth	Growth in electricity demand is driven in part by trends in the overall economy

Objective Function

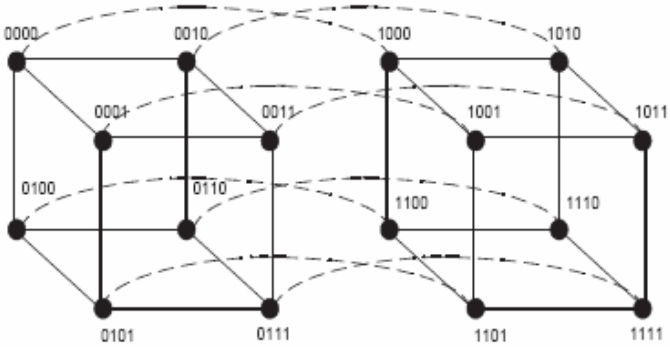
The load Q is closely linked with the n-dimensional Contract Matrix **Wn**

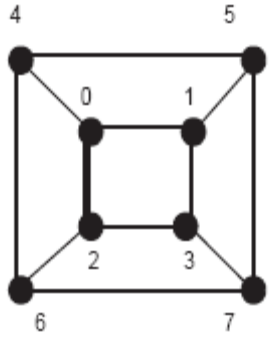
$$\left[Q_i \propto \sum_{i=1}^{k} W_n^k \right] \propto e_r$$

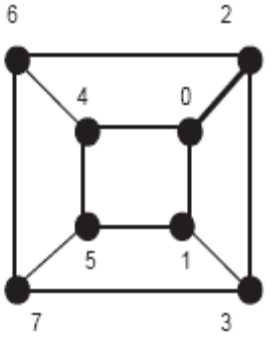
$$\sum_{j=1}^{n} \left(Q_j - L_\Delta - L_E \right) * SMP + \sum_{i=1}^{m} \left(Q_i^a - L_i^a \right) * SMP = 0$$

Where Matrix **W** represents closed contracts between Suppliers and Consumers and **e** is a multidimensional stochastic vector, representing climate and behavioral uncertainty.

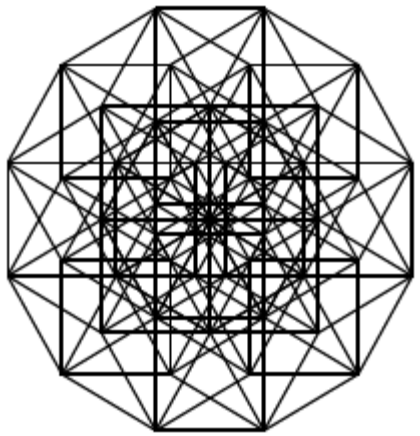
Hypercube Model and Clustering

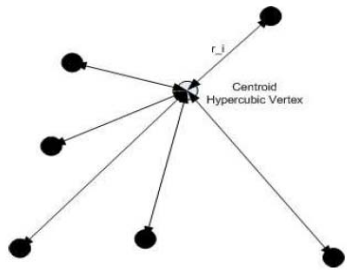






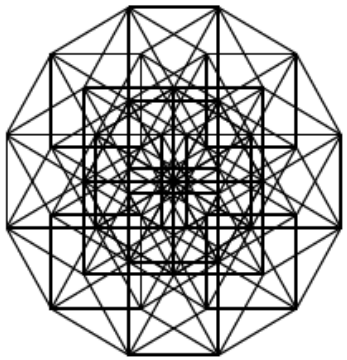
$$xy \in E \Leftrightarrow \varphi(x)\varphi(y) \in E', \forall \{x, y\} \in V$$

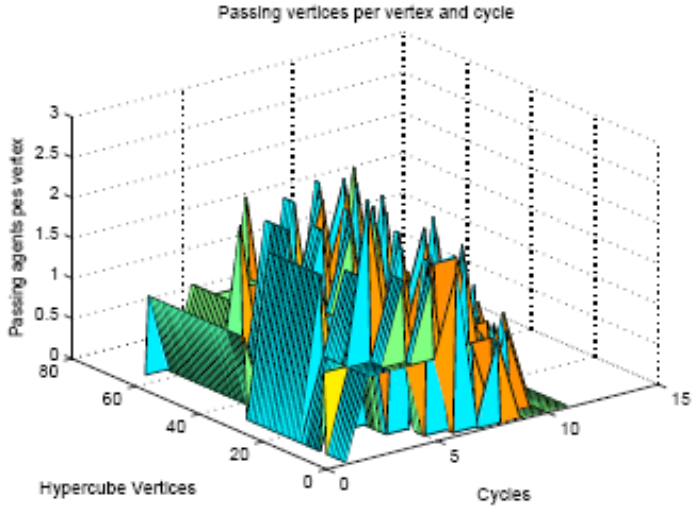


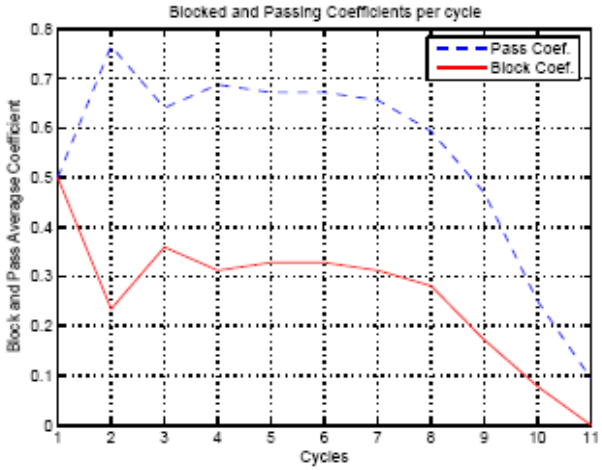


$$r_i(c_i, x_i) = \|c_i, x_i\|_p \Rightarrow \left[\sum_{j=1}^{n=4} (c_i, (x_i)_j)^p\right]^{1/p}$$

64-dimensional Hypercubic Simulation

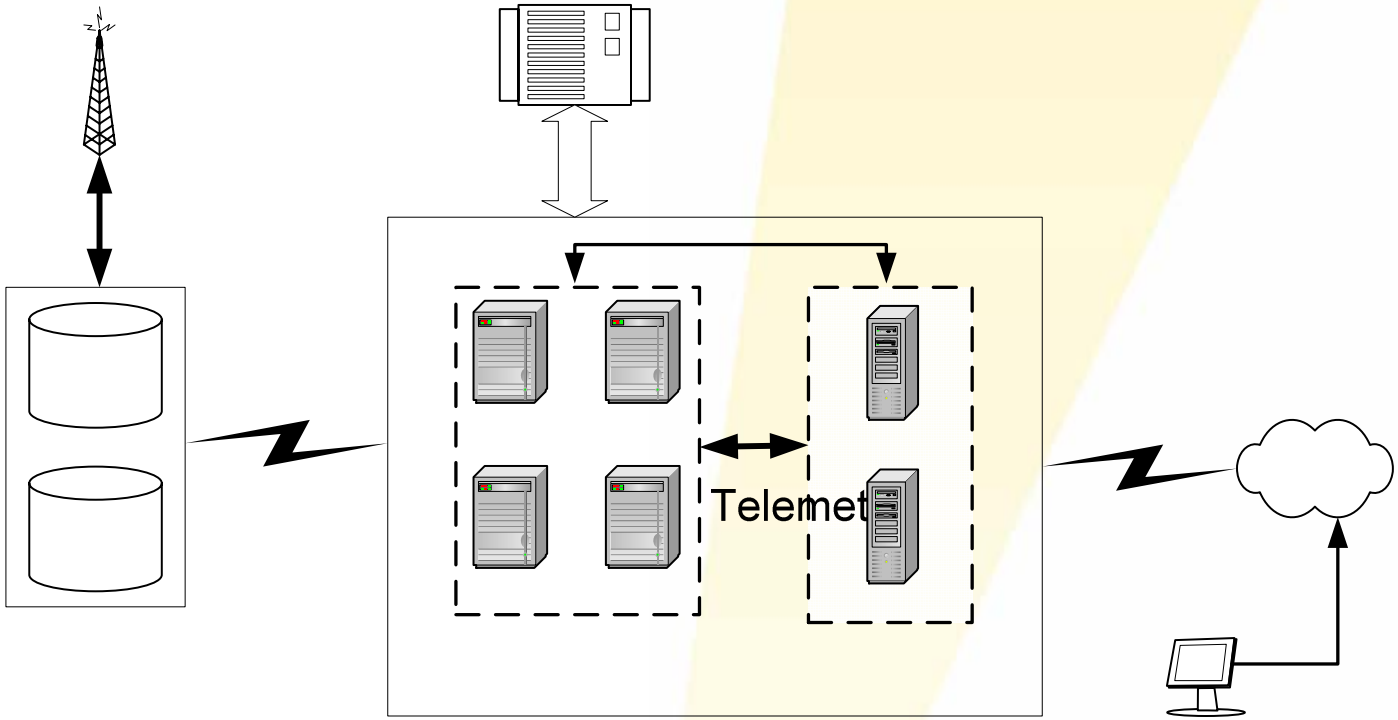




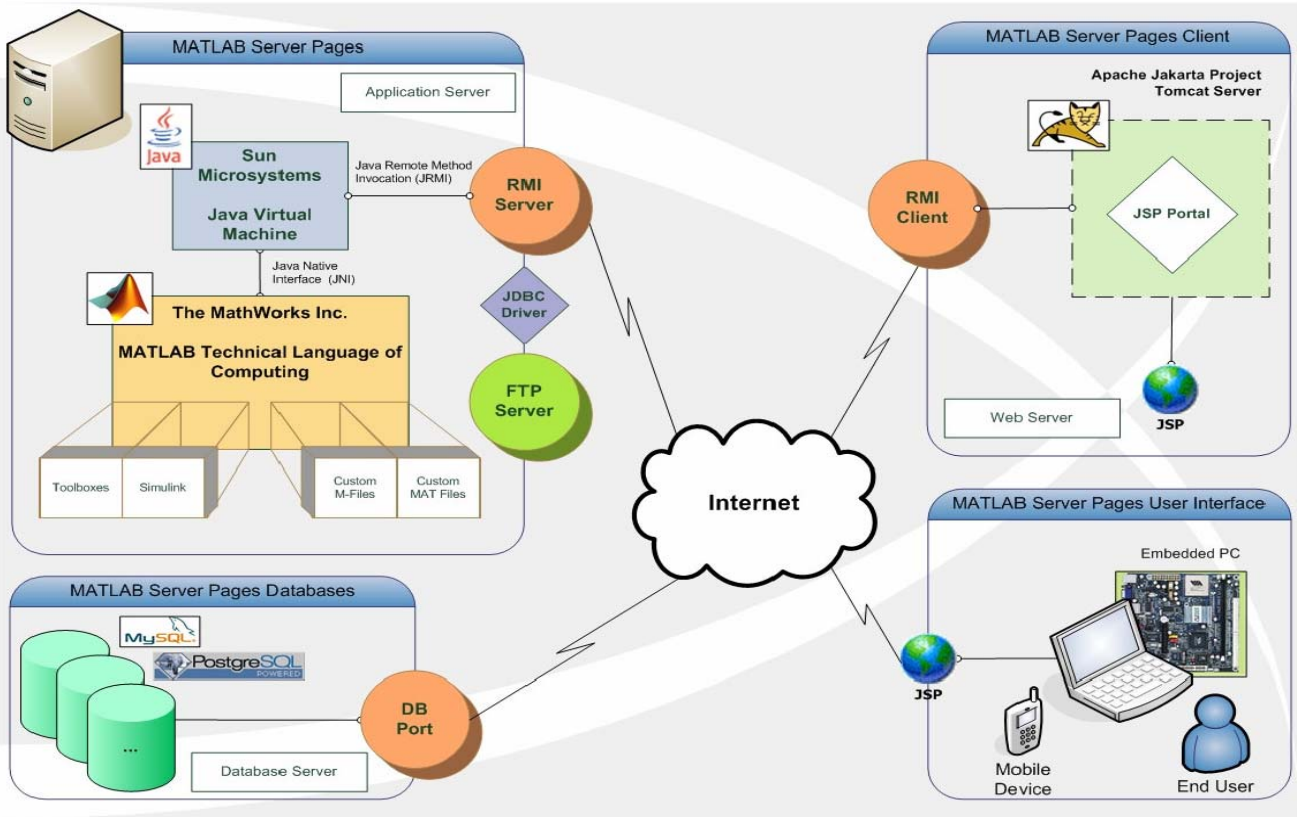


Random release of agents in a distributed Hypercube and measure the collisions and double-norm clustering calculations. We start with a random Valiant-based permutation and then deterministic routing for norm-clustering

EMIR General Topology



Matlab Server Pages (MSP)



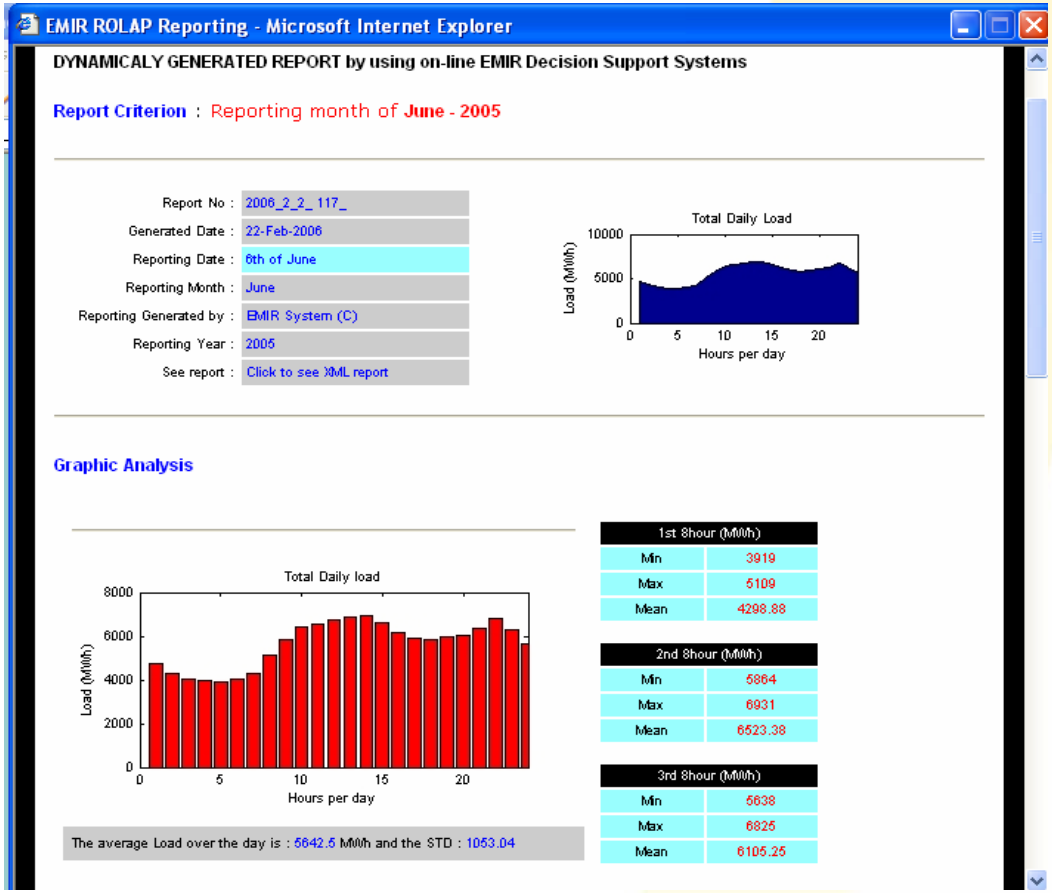
Innovative Research

- Web Energy Dashboard and dynamic KPIs
- Dynamic Energy Pricing and personalized Services
- Free Web energy CRM like energyforce.gr
- Internet-base load transfer between customers
- Energy dynamic pricing and mobile Energy Contracts
- Internet-based energy auditing and e-minimization
- ADSL-based Energy customer profiling (EMIR@home SC)
- Two successful National Patent applications to OBI-Greece
- **2nd Innovation Prize at National Innovation Contest 2006 from OTENET ->** http://www.innovation2006.gr/gr/
- EnergyRank algorithm can create the first Energy Google ?

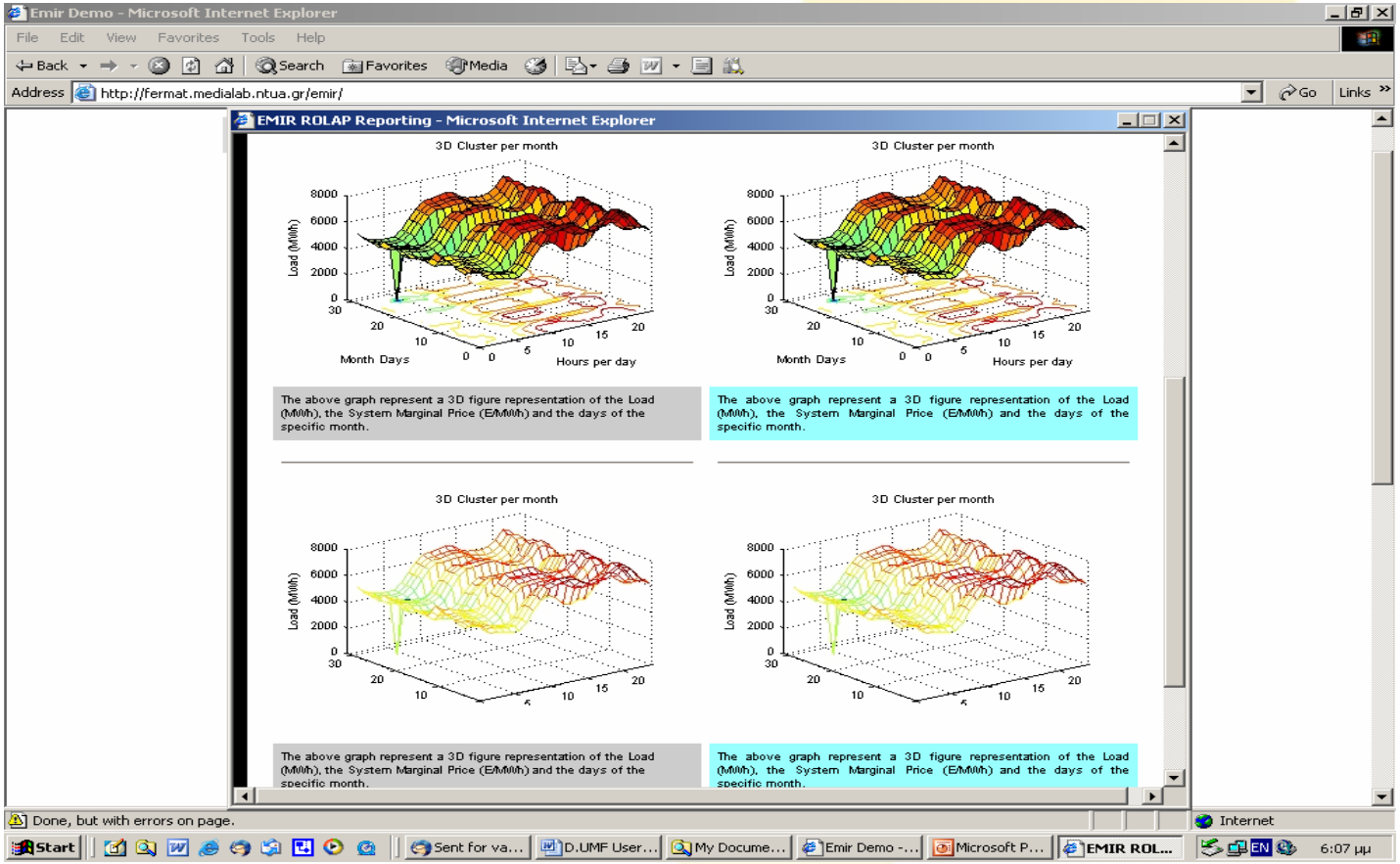
Impact and Conclusions for Services

- Energy Customer Slot Guidance (E.C.S.G.) and shaping
- Better management of total energy usage and Peak Control
- Get details about the amount and timing of your energy use
- Identify and implement operational strategies to control load factor, peak load requirements and reduce energy waste
- Understand and improve Consumption & Statistical patterns
- Secure a better variable cross-correlated dynamic pricing from the retail energy markets with personalization
- Highlight anomalies in electric consumption
- Energy suppliers can acquire faster data enabling proactive energy management
- Reduce the risk of the energy business in a volatile market
- Manage peaks to avoid spot market energy purchases

Output Graphs



Output Graphs



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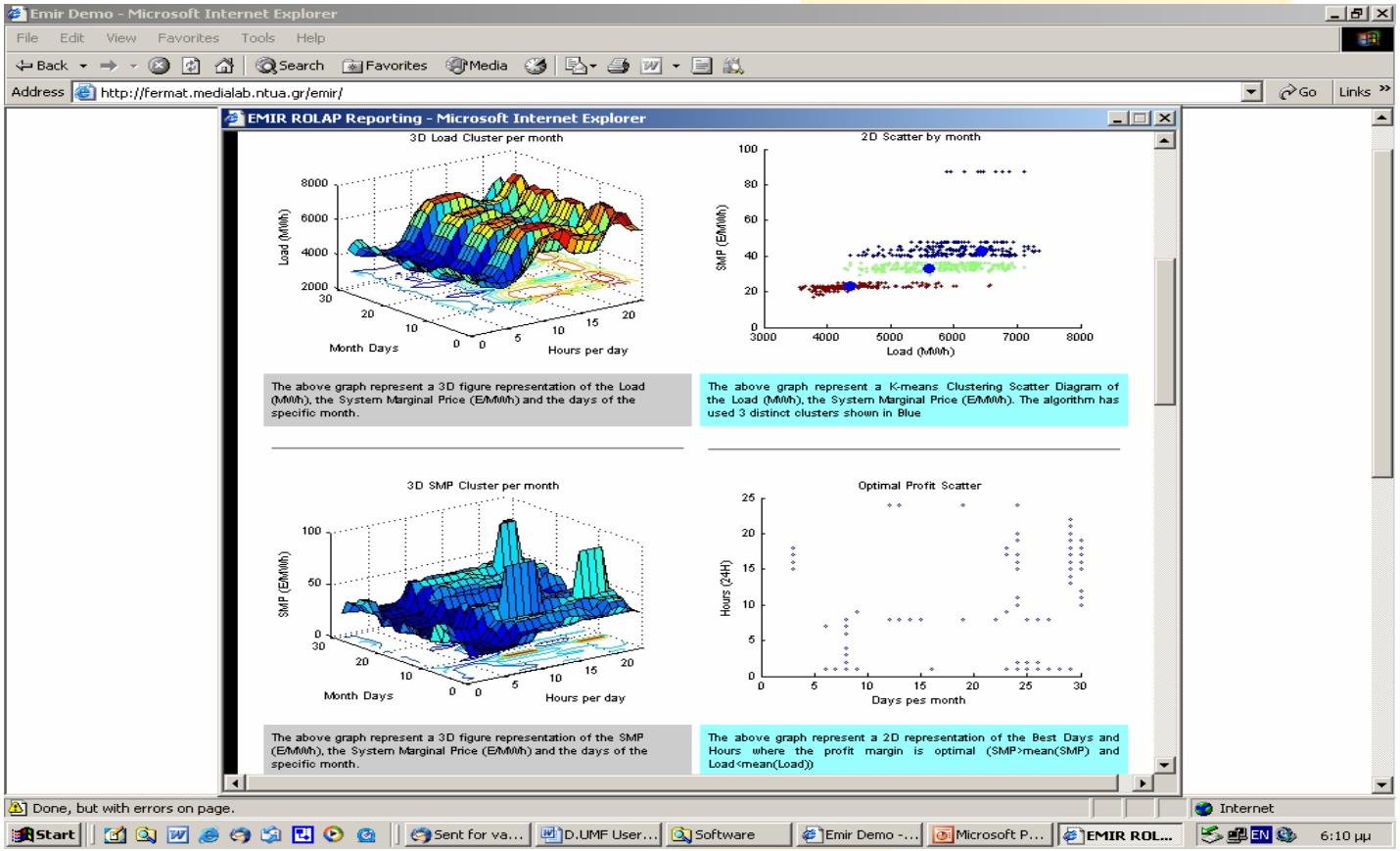

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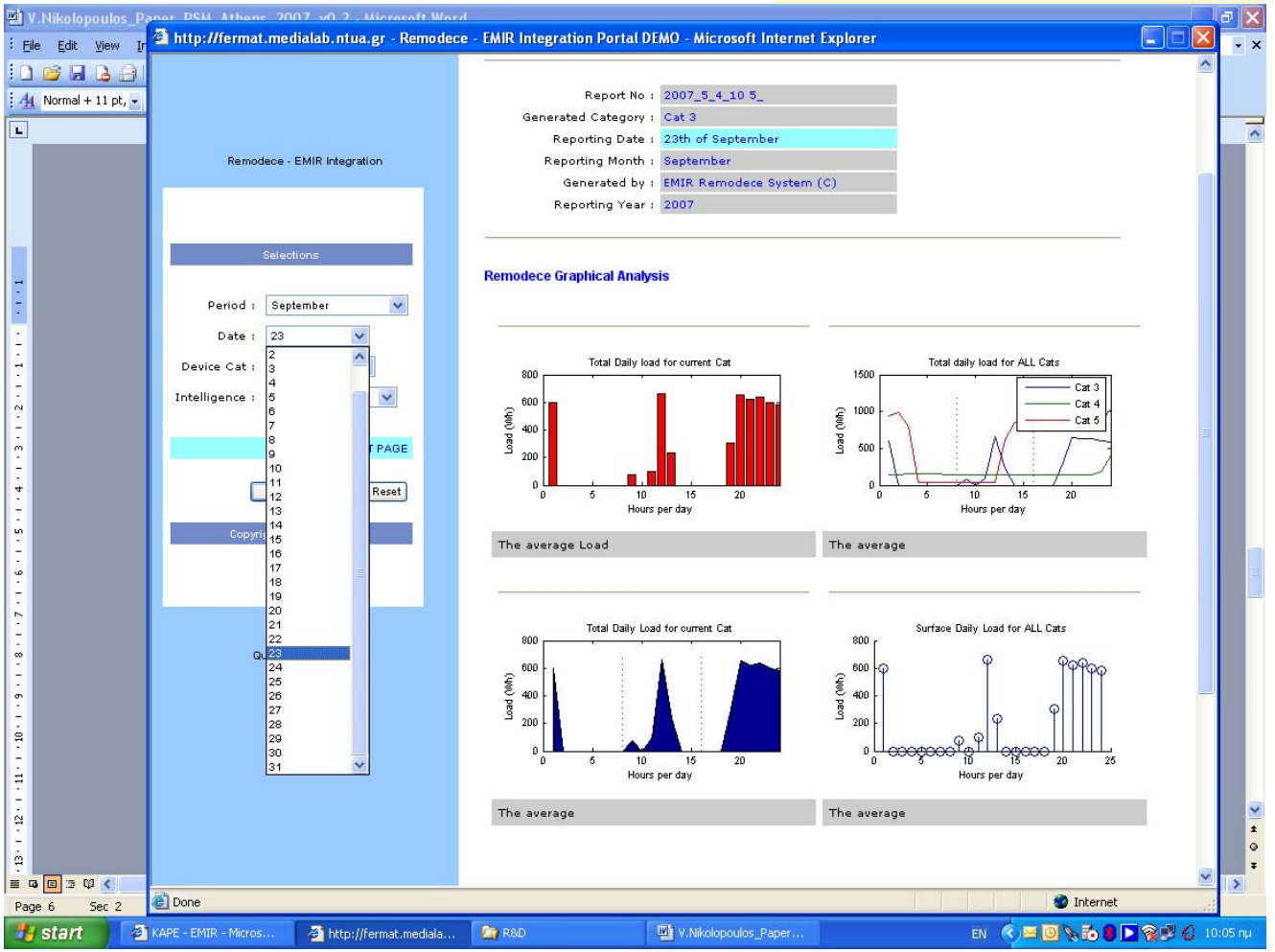
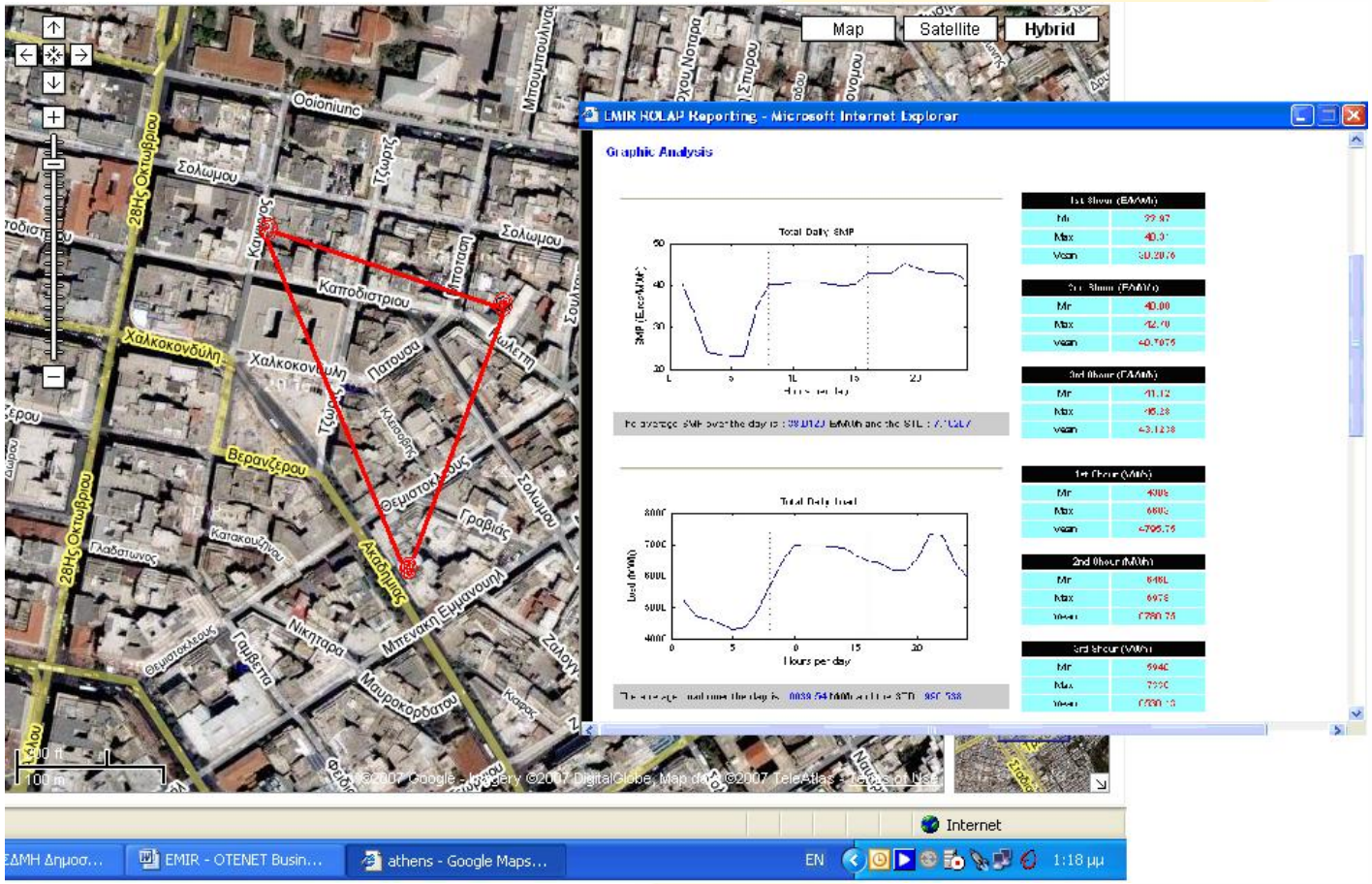


Energy location-based Services



Publications and Patents so far…

"*A complete Ontological Model for effective web-based Energy Management through a Hypercubic Semantic Grid*", Vassilis Nikolopoulos, Vassili Loumos, 2nd Panhellenic Conference of psdmh, May 2007, Athens GREECE

"*A Web-based Information System for Optimal Energy Management*", Vassilis Nikolopoulos, Vassili Loumos, T.E.E. Energy Minimization Research Day 2006, Ac. of Sciences & NTUA

"*A Web-based Information System for Optimal Energy Sources Mamagement through Ontologies and Hypercubic Clustering* ", Vassilis Nikolopoulos, Vassili Loumos, Energy 2006 International Conference, Athens Greece

"*A Web-based system for optimal Energy Sources Management, through Ontlogies and Semantic Clustering*", Vassilis Nikolopoulos, Vassili Loumos, presented at the Technical Chamber of Greece Research Confernence, 2006

"*A web-based Energy Decision Support System for dynamic knowledge energy management and automatic intelligent reporting (EMIR)*", Vassilis Nikolopoulos, Vassili Loumos, Eleftherios Kayafas, **Under preparation** for Journal

"A new approach for optimal knowledge extraction from heterogeneous web sources, using hypercubic clustering", Vassilis Nikolopoulos, Medialab NTUA 2005. White research paper at Medialab

Holder of **Patent with ref.no. 20060100249** with title : *A web-based Energy Search Machine and Decision Support System for optimal management and cost estimation of energy sources*.

Holder of **Patent with ref.no. 20060100287** with title *: A web-based system to implement energy transactions and energy load commerce for home users through automatic energy management and energy credit-coupons*

Thank you and … questions ?

http://www.medialab.ntua.gr/vnikolop/

http://www.intelen.gr