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LEASING APPLICATION SERVICES IN E-COMMERCE MARKETS

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Abstract

This paper describes a novel IS architecture for an Energy Management System (EMS) that administers service leasing in a closed marketplace. The field study seeks to discover generally applicable requirements and constraints for domain specific E-Commerce architectures such as the EMS. The finished system will manage a distributed electric power market in a commercial hi-tech business park. EMS facilitates market interaction indicative of principal-actor relationships and auction models. The EMS E-Commerce model differs from typical outsourcing or Application Service Provider models. EMS relies heavily on Component Based Software Development that allows developers to configure the architecture in response to changing market participant roles. A system architect constructs the EMS from software components encapsulating mission critical electric power and IS services. Those service components are leased over the Internet in order to meet changing circumstances in the market and domain. Jini™ provides the computational infrastructure used by the EMS to establish and execute service leases on components. Preliminary results indicate the Jini™ architecture is an appropriate technology to develop the EMS and marketplace.

Keywords: E-Commerce, architecture, negotiation, energy IS, Jini ™

Introduction

Our information society relies heavily on electricity. This dependency is deeply entrenched as evidenced by the problems in the California electric power crisis. Electric power is more mission critical to the IT industry than any other infrastructure if you consider power quality and reliability service implications for hi-tech firms (Kim and King 2000). In addition, the economic well being of the U.S. is tightly coupled with the electric power industry that has retail sales exceeding those of the post-secondary education, telecommunications, or automobile industries (Brennan 1996). E-Commerce markets supplying electric power generation, distribution, and/or transmission are difficult to design and often fail (Borenstein et al. 1997, Cardell et al. 1997, Chao and Peck 1996, Diamond and Edwards 1997). Distributed E-Commerce systems, information technologies, and the Nation's electric power system are intimately bound together. That relationship introduces complex developments making it difficult to predict or analyze the market. The co-evolution of emerging distributed energy (i.e. electric power or electricity) generation (e.g. micro-turbine generators, fuel cells, or photovoltaics), IS, and IT technologies coupled with fluctuating deregulation policies will lead to unpredictable, but significant developments in the coming years.

Interesting questions emerge regarding this co-evolution when one considers automating E-Commerce marketplaces and negotiation processes. How will the market participant roles change when basic functions such as negotiation and accounting are automated? McAfee and McMillan (1997) have described markets where the buyer and seller roles were executed by computer in specific research domains to capture market efficiencies. The "most promising application areas for automated negotiation include retail e-commerce, electricity markets…" (Sandholm 1999). However, new research perspectives are needed to answer such questions and verify these assertions. This paper was undertaken to describe such research using a concrete and germane example from the electric power industry. This work is intended to help frame future research efforts.

The primary intent of this paper is to show how specific domain characteristics can lead to important architectural considerations and interesting E-Commerce opportunities. Also presented is the Energy Management System (EMS) architecture and computational infrastructure demonstrating the importance of a leasing mechanism to E-Commerce. Unexpected constraints and configuration possibilities were discovered during the EMS design effort. (Whitehead et al. 1995) noted that software architecture is a "necessary but not sufficient condition for the creation of a marketplace”. Therefore, the essential issues arising from domain specific socio-technical interactions as discussed below will illustrate additional important aspects that emerged.

Market making mechanisms embedded in software, hardware, standards, or policies can facilitate interactions. E-Commerce has arisen from IS and IT architectures. Yet, E-Commerce intersects several other research areas such as economics, policy, and network theories. In the electric power domain, the different intersecting actor roles, complex configurations, and market making mechanisms raise questions regarding the embedded mechanisms in the underlying architecture. To examine these integrated drivers, several research approaches (e.g. agency theory) and classifications (e.g. business to business—B2B) were considered for this work. However, none adequately addressed the energy marketplace complexities found at the field site, which will represent a time-based revolving resource spot market. Resource access is managed using leases similar to a conventional equipment lease. Those “services” include back office computational capability for the support of energy forecasting, power quality, or power reliability. Based on their evolving business strategy, commercial park tenants (there will be approximately 165 firms occupying 2.4-million sq. ft. in 43 buildings upon completion) change their energy tactics by utilizing services. Field observations raised pertinent questions having implications for future research.

- What sort of models, methods, and information system infrastructure will E-Commerce researchers need in order to study these tightly coupled developments?
- What sort of IS and IT configurations are needed to facilitate a market where role reversals are common?
- Is the necessary technology even available?
- What are the socio-technical inhibitors to market creation?

Section 2 initializes the examination of these questions. The discussion pivots around examining tool development issues and component leasing. Section 3 provides insights into domain specific institutional and socio-technical complexities. Some market opportunities are also enumerated. Section 4 ties together certain deregulation efforts, E-Commerce products, and market ramifications for the field site. Section 5 describes the EMS architecture and technical implementation details. Then it loosely couples them with abstracted domain drivers and architectural aspects. Section 6 uses scenarios to elaborate more of the domain specifics. Section 7 summarizes the discussion to inform future research efforts by enhancing the key concepts.

Electric Markets: Components, Leasing

The term "component" is traditionally used in engineering to abstract and/or aggregate functionality. Software engineers convey similar meaning and facilitate examination of composite software applications by extending the abstraction (Perry and Wolf 1992, Shaw and Garlan 1996, Taylor 1996). Component Based Software Design (Clements 1995) is becoming an economically viable option to in-house development. Software components encapsulate service functionality, but also abstract services further by presenting only limited functionality (i.e. via an API—Application Programming Interface). Services represent complete software applications, technological artifacts, entities, or computational algorithms.

EMS components represent mission critical electric power and IS services. These software components are leased over the Internet. By extension, a component can be a legal proxy (e.g. an authorized delegate representing another entity in the traditional marketplace) or a legal instrument securing a service such as electric power generation. Therefore, leasing a component establishes a contract to convey a service for a specified period and prearranged payment. Component leasing models are theoretically viable only if the underlying architectural infrastructure exists that can operate the marketplace in compliance with requirements such as security, maintainability, and the “-ilities” of software engineering.

Architectural constraints create technological impediments for B2C E-Commerce (Rose et al. 1999). Economic constraints and incentives factor into the system development process at many levels of analysis (Boehm 1976, Brooks 1995, Clements 1995). These economic pressures demand rapid changes, thus challenging the current Application Service Provider (ASP) model in complex domains such as electric power. Component reuse reduces costs and can accelerate development, but it is difficult (Taylor 1996). Leasing models could facilitate reuse of information systems architecture (Zachman 1987) components. To lower costs, firms can quickly experiment with component configurations using leasing. Assembling components using patterns may address rapidly emerging market constraints. The leasing concept applied in a component marketplace Whitehead et al. (1995) provides flexibility to firms seeking temporary relief from market pressures. EMS architectures constructed from marketplace components may be a plausible mechanism given the initial findings from the requirements analysis. During this ongoing engineering field study of distributed generation, this work will continue examining the goodness of fit of the leasing model and component marketplace using empirical data from the site. Domain constraints create intricate socio-technical webs of requirements effecting the component marketplace dependencies.

Energy Management System Domain

Background

The electric power domain is critical to the U.S. economy. The search for effective and immediate solutions to electric power shortages and other industry problems provide sufficient urgency to understand socio-technical domain constraints better. Information systems are crucial components of the electric power industry. The North American electricity production and delivery networked system (i.e. the “grid”) must synchronize huge quantities of data from multiple organizations on a time-stamped basis. Then competitors cooperatively balance the books. Under the traditional Investor Owned Utilities (IOU) model, operators scheduled generation to meet load (spontaneous demand from users). These experts used sophisticated forecasting models and pertinent data including consumption patterns, weather, and seasonal variances in the models.

Electricity transmission trading using the Internet has drastically changed the system requirements (see Federal Energy Regulatory Commission, FERC, below). Energy spot market exchanges are now active, viable, and monetarily significant. However, those exchanges are volatile niche markets with high risk and payoffs. Real-time production domains demanding 100% reliability and process control magnify risk. Monopoly utilities had little risk before the early 1990's. A regulated process established the cost of electricity under the old governance regime in California. Because of this process, IOU recovered the costs of production as part of the total cost to provide electricity services (i.e. customer rate base). Utility compensation is based on cost accounting data. Therefore, the primary utility objective was to justify costly monopolistic expenses through complex software-facilitated data accounting practices. Economists asserted that utilities were exercising market power by charging competitors inflated prices for transmission of power (referred to as “wheeling”); thereby constructing barriers to entry via cost-shifting (Diamond and Edwards 1997). To counteract their market power, regulators’ forced utilities to separate out (i.e. spin off) certain internal organizational functions and business units.

Electricity Exchanges and the Internet

FERC’s notice of proposed rulemaking Order No. 888 and 889—appropriately named Open Access Same-Time Information System (OASIS)—started deregulation in earnest. The OASIS thrust was twofold (1) “functionally separate transmission and wholesale power merchant functions” and (2) create OASIS web sites. FERC moved the utility’s high voltage “wheeling” of power and the associated accounting practices to a public Internet forum. At the same time, California’s law makers and Public Utilities Commission crafted Assembly Bill 1890 (AB 1890) converting the IOU into Utility Distribution Companies (UDC) providing regulated distribution services (i.e. low voltage). Power generation competition began on April 1, 1998. The old vertically integrated organizational structure had internal business units handling all the services listed in Table 1 (below). Now, numerous firms occupying emerging market niches (e.g. columns) are offering those same services.

Internet use in deregulation demonstrates policy makers’ awareness of E-Commerce opportunities. Consequently, firms are repositioning themselves in new electricity exchanges. With such dynamic change, existing systems need to be quickly adapted for emerging E-Commerce. Another result of AB 1890 is the mandatory participation of IOU in the newly created Power Exchange. It is the world’s largest electricity market of its type with power trading averaging 517,842-megawatt hours (MWhs) daily with a total of 187 million MWhs traded in the first year. Direct access customers can circumvent the local UDC for services. Direct access customers are increasing by approximately 5,000 per month. In California, over 1 percent of total residential and over 20 percent of the industrial customers have chosen direct access. Electricity sales to direct access customer were 22,441 GWh on an annual basis. Revenues from direct access sales are roughly $540 million or about 14 percent of the Power Exchange’s $4 billion competitive electricity commodity market (CEC 1999). Federal, state, county, and local officials show an increasing interest in creating an environment conducive to direct access customers.

EMS Facilitating Markets

Direct Access: B2B Market Driver

The developing market scenario includes selling excess energy to other commercial business park tenants or the primary grid. Commercial and industrial park owners are positioning themselves as value added energy resellers or simply agents. Table 1 (above) shows some services a park may choose to offer (i.e. the **XX** boxes). However, a park landlord (i.e. property owner) is not likely to have an advanced energy IS. Commercial off the shelf energy IS will not resemble the highly advanced custom tools

Table 1. Electric Power Market Services in a Deregulated Market and the Types of Service Providers

Electric Power Service Provider / **Functional Service in Niche Market:** (Probable future **landlord functions in bold**)	***Energy Service***	**Independent**	Utility Distribution Companies	Scheduling Coordinator	Power Exchange	Metering Service Providers	Generator	Metering Data Management Agent
Executing Energy Exchange Spot Market				**XX**				
Participate in Energy Spot Market Exchange	**XX**			**XX**	X		X	
All electric service elements consolidated bill	**XX**							
Scheduled wholesale energy billing & payment	**XX**						X	
Payment to UDC for distribution, etc.	**XX**							
Settle SC & ISO charges	**XX**			X				
Provide validated metered usage data	**XX**					**XX**		**XX**
Measure energy consumption						**XX**		**XX**
Provide real-time price signals								**XX**
Collect customer payments	**XX**							
Provide aggregated data; settle ISO charges		X		**XX**				
Control of High Voltage Transmission		X		X				
Data transfer for ESP and consolidated billing			X					
Control of Low Voltage Distribution			X	X				
Congestion Management of Transmission		X						
Contracted ancillary services billing & payment		X		X			X	

that the IOU possesses. The landlord could outsource their needs based on several drivers (Goo et al. 2000). Typical Application Service Provider offerings lock a landlord into a particular technological trajectory; unwise in today's volatile electricity market. A semi-custom distributed component EMS may be a viable solution by providing the landlord flexibility in developing and changing the energy spot market of the park. Requirements for the component architecture include the need to enhance the natural market making mechanisms found in the domain and use standard Internet technologies. Coordinating park resources through leases addresses these objectives. Coordination is difficult in B2B interactions (Malone and Crowston 1994). The EMS functions as a coordination medium by leveraging market mechanisms.

Inflexible firms have failed as a result of electric power deregulation. A firm's lack of agility in the market often reflects the dynamic characteristics of its information systems architecture. Legacy systems with static code quickly become a millstone dragging an organization down when in competition with agile organizations (Truex et al. 1999). The recent market failures are only the beginning as increased actor autonomy brings more complex and spontaneous market interactions including role reversals. Unexpected market failures due to ineffective deregulation encourage new E-Commerce arrangements. Oracle, for instance, constructed a power substation after determining that a blackout would cost them $1 million per occurrence. IBM, Sun Microsystems and Intel are all moving quickly to offer power efficient hardware to replace current offerings. (Hi-tech firms such as server farms especially need these technologies and services). The egalitarian principles held by the Internet's original designers' (King et al. 1997) are embedded and reflected in its architectural design. Hence, its architecture does not naturally conform to markets because of institutional mechanisms resisting the changes (Lessig 1999). These factors must be considered while evolving the Internet's architecture to support new E-Commerce markets. As a specific case, an EMS must evolve in parallel with the Internet when exogenous factors create unforeseen impediments (e.g. network externalities).

Leveraging Leasing to Lower Costs

Leasing additional electric power services or IS application services via the Internet can rapidly augment a firm's agility. The downloadable proxy functions as a delegate component. As competition grows among lease grantors (lessors), the component market will tend toward equilibrium (Coase 1990). Once the marketplace has equalized, additional service offerings will have an extraordinary affect. Long term commitments are not mandatory within the component-leasing paradigm. E-Commerce marketplaces should theoretically decrease costs for resource lessees leveraging short-term leases. As the lease interval, choices regarding suppliers will increase incrementally as a function of lease length. This model fosters experimentation in a field experiment using the component marketplace as a dynamic component repository or cache. The implementation will use the computational infrastructure in Figure 1 to facilitate cost reductions. A service lessee maintains resource control after agreeing to the component's embedded lease agreement initiated during the download sequence. The integration of the customer needs and preferences of the developer set the lease agreement.

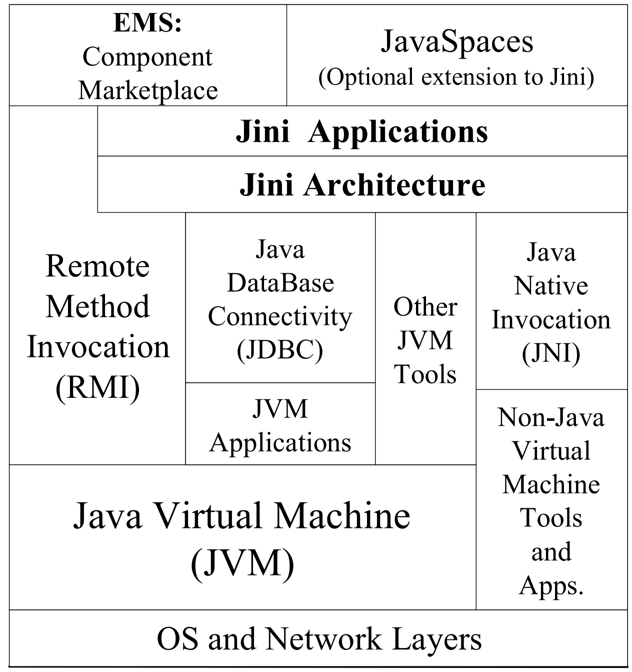

Figure 1. EMS and Infrastructure

The E-Commerce leasing model described above imposes numerous requirements regarding the information infrastructure. Those constraints must be implemented in future research efforts without sacrificing security. The leasing approach requires that the service developer/lessor and consumer/lessee strictly conform to prearranged leasing interaction protocols. Considering architectural issues such as these *a priori* will reduce market barriers and accounting costs. Using temporal control of components addresses some of these requirements. Constraining the leasing mechanisms embedded in the computational infrastructure facilitates resource exchange. Automatically enforcing the appropriate built-in mechanisms (e.g. payment collection) in conjunction with programmatically constructing leases can reduce monitoring costs. Payments will be transferred between the participating entities per the successful lease negotiation, finalized agreement, and implementation. This process streamlines the operation. The next section describes the architecture used for this model.

EMS

Technical Architecture Details

The EMS architecture depicted in Figure 1 (above) is essentially a heterogeneous type. It incorporates aspects of homogenous architectures (Shaw and Garlan 1996) including call-and-return systems (e.g. OO systems), independent components (e.g. event systems), virtual machines (e.g. interpreters), and data-centered systems (e.g. repositories such as blackboards). EMS uses Java™ technology extensively. Services are implemented as components Using Java™ interfaces. An architect uses interfaces as strongly typed search criteria for specific services in the blackboard architecture style (Freeman et al. 1999, Shaw and Garlan 1996). Component proxies are stored in common repositories. Client-server mechanisms provide access to the repository, facilitate searching, communicate the lease negotiation, and retrieve the proxy.

EMS is built on top of Jini™ technology (Arnold et al. 1999). Early requirements analysis determined that the Jini™ technology was a suitable computational infrastructure for the EMS prototype. Optional infrastructure functionality is available through JavaSpaces™ technology (Freeman et al. 1999). JavaSpaces™ are conceptually configurable as a component marketplace environment. A detailed discussion of JavaSpaces™ is not possible or directly relevant in this paper. Jini™ encapsulates the architectural characteristics needed to meet the E-Commerce model requirements and is suited for a flexible EMS component market making IS. A great deal of overlap exists between a market lease and the Jini™ "lease". Both Jini™ and RMI make "services" available to park participants using the leasing mechanism. In theory, "federating" or chaining "lookup servers" together through cross registration can extend the marketplace with more "communities" (Sun Microsystems 1999). Firms participating in these communities can publish any of the market component services alluded too earlier as Jini™ services on the lookup servers.

Park participants exchange service components according to the underlying E-Commerce model. The process is facilitated by the lookup server acting as a directory service (Arnold et al. 1999) or blackboard running somewhere on the Internet. Extending this service model to information system architectures is a natural progression. The Jini™ infrastructure facilitates creating different EMS architecture configuration "instances" (i.e. as in object-oriented programming to instantiate an abstract class).

EMS Implementation Details

Figure 2 shows an EMS implementation for the commercial park using the client-server architectural style. This example architecture facilitates the separation of concerns along economic control boundaries reflecting an asynchronous process. The figure depicts two communities (circumscribed by dashed boxes), the landlord and tenants. The federation of the communities (shown by the two-headed arrows) demonstrates a centralized control paradigm where the landlord maintains significant control of the process. This artificial division between the landlord and tenant community explicates and highlights the leasing mechanism. Tenants (clients) download service proxies with both legal and computational standing distinguished by their 128-bit unique identifier (Sun Microsystems 1999). The service ID is nearly impossible to copy if the infrastructure employs the appropriate security measures. Entities will use the ID for contract accounting, automatic payments, and dispute resolution when leasing services.

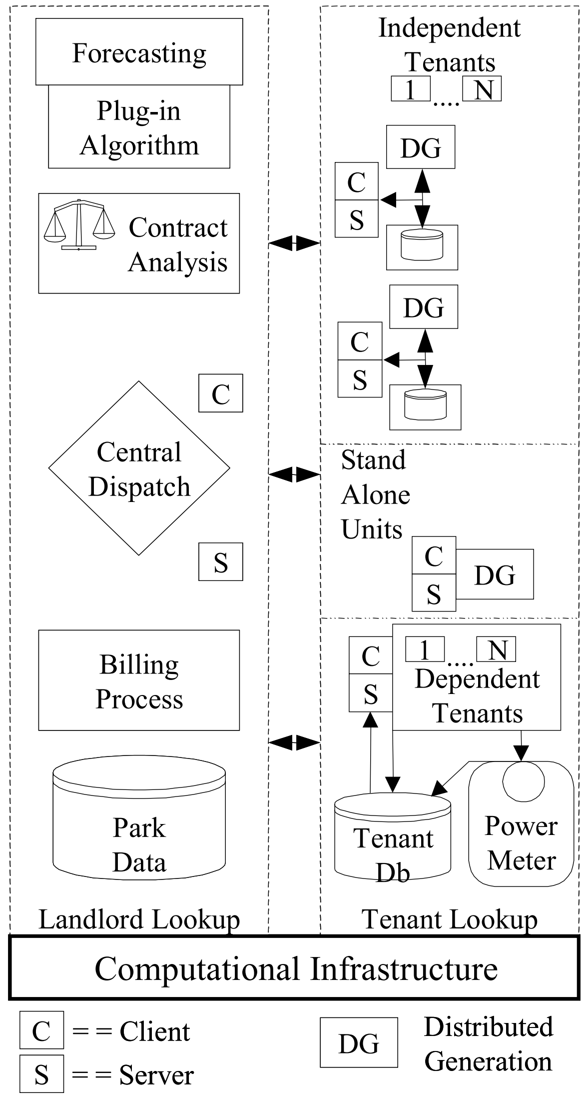

Figure 2. EMS Client-Server Instance

The underlying infrastructure distributes specific component resources. For example, database service instantiations in Figure 2 are inaccessible unless the lessee first obtains the proxy. These services execute on smart meters measuring tenants' energy consumption. The tenants will use the component marketplace to coordinate distribution. However, within the communities the free flow of events actually contributes to emergent communication patterns analogous to spot market interactions. Depending on the process step and function, an entity can change status from client to server or vice versa (thus the "C" and "S" attachments) demonstrating role reversals. In a client role, EMS actively seeks data from tenants. The EMS will query tenants depending on expected load factors during E-Commerce market operations. They are petitioned to sell their distributed generation electricity. Alternatively, based on their own load factors the tenant may solicit buyers or additional generation using market interactions and leasing mechanisms. The EMS architecture makes such flexible interaction possible.

EMS may address rather lightweight or heavyweight services, depending on the resource (e.g. a relay switch, generator, or neural network forecasting software). The park is still under construction, but the final implementation will likely employ thousands of servers running intermittently throughout the park. Remember that these servers provide access to a component's resource per the terms of the lease. Lessees will legally own exclusive or shared service access depending on the exchange agreements. However, security constraints regarding access generate constricting requirements that will evolve during the remainder of the field study. Table 2 (below) shows an example set of domain relationships between soft constraints (i.e. drivers) and design issues (i.e. aspects). The table aggregates some of the implicit and explicit nuances discussed in this paper. During development, these tables are evolved into constraint sets used for requirements analysis and architectural design to parameterize service components. The following two sections provide further details through scenarios that are widely used for requirements engineering as well.

Table 2, Some Domain Drivers and Architectural Aspects: Linking Domain Specifics and Ems Characteristics

	Data Management	Energy Forecasting	Automated Accounting	EMS Expertise Implementation
Power Quality on Demand	Capture service specific data	Exchange heuristics with precise algorithms	Charges for higher quality services applied on demand	Reduces need for device installation
Continuous Reliability	Monitoring capability	Domain centric statistical significance	Capture service specific variations	Domain specific knowledge base
Economic Relief via Marketplace	Track and analyze low cost services	Accessibility to low cost scenario analysis	Freedom of vendor choice; i.e. service providers	Market driven price for expertise
Outsourcing	Scalable to client	Configurable to firm	Integrate to firm's system	As needed basis
Integration of Policies	Data ownership and sharing practices	Aggregation of different institutional policy levels	Balancing of the books using exchange policies	Market driven policy nuances
State change: Brownouts, Blackouts (e.g. Islanding)	Persistence available across state changes; diagnose source of disturbance	Shift between algorithms used for normal and disturbed states	Stable accounting practices across disturbances in order to assess damages and assign responsibility/blame	Consistent emergency management plans
Role Reversals Allowed	Regardless of function in market	As primary recipient or intermediary delegate	Capture and account for context/role specific charges	Shared ontology regarding roles
Maintainability and Cost Reduction	Capture evolutionary costs and patterns	Arrange coordinated and most cost efficient maintenance schedules	Track incremental software costs without excessive human involvement	Quantified service statistics
Capital Recuperation	Transaction tracking	Ongoing financial analysis	Integrate transaction results dynamically	Secure transaction mechanisms
Direct Access for Customers	By-pass intermediaries	Scoping the matched problems and solutions	Service embedded in device or proxy	Reduction of consultant costs
Participant Market Power	Offset market power via data sharing	Uniform services offered to all firms	Reduction of complexity	Embedded control mechanisms

EMS Scenarios

Power Quality

The EMS must address simultaneous emerging scenarios at the field site. The commercial park design focused on supplying various services to tenants. The park developers installed additional infrastructure, which allows the operation of the energy “micro-grid”. The micro-grid infrastructure is configurable into different topologies to test various engineering designs. For example, one configuration is actually two separate micro-grids within the park: one for high quality power and the other for inexpensive power. Some firms may not need both of these services 24/7 (i.e. 24 hours a day, 7 days a week). Many tenants would prefer the inexpensive power when sensitive hardware is not operated. Therefore, a firm may be a consumer during the day, but reverse roles to a producer after hours. They would then sell excess generation from their fuel cell to neighbors, such as the biotech firm who is always shopping for the best quality of service (QoS) 24/7.

Firms can lease QoS service devices in the marketplace facilitated by the EMS. Rule based strategies executing semi-automatically will manage resources (e.g. fuel cell access) through leases. Leases allow firms to conduct daily operations by executing short-term extendable contracts at the lessor's discretion. Therefore, during crunch times (i.e. demanding production schedules), the software developer can bid against the biotech firm for the late night QoS. The winning lessee downloads the client proxy, which then monitors and/or accesses the service. The internal transaction monitoring of Jini™ facilitates the secure accounting. Meter data becomes secondary validation available when the need arises.

Economics

Recently in California and other deregulated states, firms have had their profit margins completely eradicated by excessive energy costs. Strategists within the firms are having difficulty reconciling the institutional forces affecting energy prices. Instead of investing extensive resources to address these issues under a long-term strategy, park tenants using EMS pursue several other tactics. The first is rudimentary: purchase the lowest cost energy either from the micro-grid or primary grid (e.g. from the utility). However, employing such a simplistic approach regarding excess energy in the park quickly exhausts the supply without solving the systemic problem.

The second proposition exercises the option to make a capital investment in distributed energy generation equipment. Unfortunately, most units come with proprietary software. EMS, however, can provide the interface allowing a firm to lease any combination of services without undertaking extensive software integration projects. For example, the firm can lease the distributed generation unit on an hourly basis to the landlord thereby capitalizing on recently purchased excess generation. The landlord then leases the necessary specialized software to run the unit from a third party vendor. After installing and running the software, the landlord then aggregates and redistributes the generation to the other tenants. The EMS is the coordination mechanism used to distribute power at market clearing prices in accordance with the original leases.

Conclusions and Future Work

Initial analysis indicates the EMS prototype architectures described above address some of the technological barriers to E-Commerce. There is significant potential regarding the utilization of short term contracts to outsource various services. The electric power industry is a natural E-Commerce market. However, additional component marketplace research is necessary to establish its affects. In this context, leasing is a powerful socio-technical market construct between actors. This approach warrants considerable attention. Further investigation into the development of E-Commerce systems using components representing services is an important research area.

The preliminary investigation indicates it is both possible and advantageous to augment E-Commerce architecture development using leasing (e.g. with Jini^{TM}). The utilization of leased components has distinct advantages. However, this is not an exhaustive treatment of the possibilities of lease usage for E-Commerce or architectures. This paper has shown the correlation between a component marketplace, service exchange, and the emerging constraints arising at the field site. Test examples have resulted in encouraging feedback. To further test EMS scalability, the prototype is currently being expanded. That effort will extend the number of complex component services available as the park is populated.

This paper has used a client-server style to draw out the nuances and distinctive characteristics of the EMS. Other EMS configurations are under investigation to determine the most effective heterogeneous information system architecture for this E-Commerce application. Leasing is one of the mechanisms facilitating the testing of new configurations. Field site participants and owners of the commercial park resources are actively creating protocols for use with the EMS to lease service components thereby extending the existing test suite. In the future, various instances will be tested using empirical data after the installation of the appropriate instrumentation. In addition, the EMS test plan will include more mission critical services and complex configurations as the experiment progresses.

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References

Arnold, K., Scheifler, R. W., Waldo, J., Wollrath, A. and O'Sullivan, B. *The Jini(TM) Specification,* Addison Wesley, Reading, Mass., 1999, p. 385.

Boehm, G. A. W. "Shaping Decisions with Systems Analysis," *Harvard Business Review,* (54:5) 1976, pp. 91-99.

Borenstein, S., Stoft, S., Bushnell, J. and National Bureau of Economic Research *The competitive effects of transmission capacity in a deregulated electricity industry,* National Bureau of Economic Research, Cambridge, MA., 1997, p. 50.

Brennan, T. J. *A shock to the system: restructuring America's electricity industry,* Resources for the Future, Washington, DC, 1996, p. 138.

Brooks, F. P. *The mythical man-month: essays on software engineering,* Addison-Wesley Co., Reading, Mass., 1995, p. 322.

Cardell, J. B., Hitt, C. C. and Hogan, W. W. "Market power and strategic interaction in electricity networks," *Resources & Energy Economics,* (19:1,2) 1997, pp. 109-137.

CEC, *Retail Electricity Market Activity through March 1999,* California Energy Commission Sacramento, 1999, p. 56.

Chao, H. and Peck, S. "A Market Mechanism for Electric Power Transmission," *Journal of Regulatory Economics,* (10: 1996, pp. 25-59.

Clements, P. C. "From Subroutines to Subsystems: Component-Based Software Development," *American Programmer,* (8:11) November 1995, pp. 23-43.

Coase, R. H. "Accounting and the Theory of the Firm," *Journal of Accounting & Economics,* (12:1-3) 1990, pp. 3-13.

Diamond, J. and Edwards, J. D., *Mergers, Acquisitions and Market Power in the Electric Power Industry,* California Energy Commission Sacramento, April 4 1997, p. 86.

Freeman, E., Hupfer, S. and Arnold, K. *JavaSpaces principles, patterns, and practice,* Addison-Wesley, Reading, MA, 1999, p. 344.

Goo, J., Kishore, R. and Rao, H. R. "A Content-Analytic Longitudinal Study of the Drivers for Information and Systems Outsourcing," *Proceedings of the 21st International Conference on Information Systems,* Brisbane, AU, Dec., 2000, pp. 3-13.

Kim, J. Y. and King, J. L. "Boundary Instances in Heterogeneous Engineering Teams: Trouble Management in the DRAM Manufacturing Process," in *Research on Managing Groups and Teams,* Vol. 3, M. A. Neale and Mannix, E. A. (eds) JAI Press, 2000, pp. 45-66.

King, J. L., Grinter, R. E. and Pickering, J. M. "The Rise and Fall of Netville: The Saga of a Cyberspace Construction Boomtown in the Great Divide," in *Culture of the Internet,* Vol. (Ed, S. Kiesler (eds) Lawrence Erlbaum Associates Publishers, Mahwah, N.J. 1997, pp. 3-34.

Lessig, L. *Code and other laws of cyberspace,* Basic Books, New York, 1999, p. 297.

Malone, T. W. and Crowston, K. "The interdisciplinary study of coordination," *ACM Computing Surveys,* 26:1 1994, pp. 15.

McAfee, R. P. and McMillan, J. "Electric Markets," in *Readings in electronic commerce,* Vol., R. Kalakota and Whinston, A. B. (eds) Addison-Wesley, Reading, Mass 1997, pp. 293-309.

Perry, D. E. and Wolf, A. L. "Foundations for the Study of Software Architecture," *ACM SIGSOFT Software Engineering Notes,* (17:4) October 1992, pp. 40-52.

Rose, G., Khoo, H. and Straub, D. W. "Current Technological Impediments to Business-To-Consumer Electronic Commerce," *Communications of the Association for Information Systems,* (1:16) June 1999, pp. 1-73.

Sandholm, T. "Automated Negotiation," *Communications of the ACM,* (42:3) March 1999, pp. 34-37.

Shaw, M. and Garlan, D. *Software architecture: perspectives on an emerging discipline,* Prentice Hall, Upper Saddle River, N.J., 1996, p. 242.

Sun Microsystems, I., *Jini™ Architecture Specification,* Sun Microsystems, Inc. Palo Alto, CA, 1999, p. 450.

Taylor, R. N. "Generalization from domain experience: the superior paradigm for software architecture research?" *International Software Architecture Workshop (ISAW-2),* San Francisco, CA USA, 1996, pp. 78-87.

Truex, D. P., Baskerville, R. and Klein, H. "Growing systems in emergent organizations," *Communications of the ACM,* (42:8) 1999, pp. 117-23.

Whitehead, E. J., Jr., Robbins, J. E., Medvidovic, N. and Taylor, R. N. "Software Architecture: Foundation of a Software Component Marketplace," *Proceedings of the First International Workshop on Architectures for Software Systems, held in cooperation with ICSE-17,* Seattle, WA, April, 1995, pp. 276-282.

Zachman, J. A. "A Framework for Information System Architecture," *IBM Systems Journal,* (26:3) 1987, pp. 454-470.