Integrating Business Services Networks and the Internet of Things: A New Framework for Mobile Software as a Service

S. Gagnon¹ and K. Cakici²

Abstract We propose a framework integrating 2 IT infrastructure technologies to rapidly deploy a Service Oriented Architecture (SOA) and Software as a Service (SaaS). On one hand, a Business Services Network (BSN) allows a group of organizations to provision and consume their respective software components as services. On the other, the Internet of Things (IoT) serves as a paradigm for mobile inter-enterprise computing, helping to integrate static (e.g., supplies, products, and equipments) or mobile (e.g., people, animals, and vehicles) entities carrying Radio Frequency Identification (RFID) and Wireless Sensor devices. We identify 4 integration perspectives, namely supplier, market, adopter, and delivery. A framework is proposed for the strategic analysis of mobile SaaS and pay-per-use vendors.

1 Introduction

The Service Oriented Architecture (SOA) has become a key approach to developing and modernizing enterprise applications. It has also created new opportunities for exposing applications to external partners. The use of XML Web Services, and related WS-* standards in development, allow for the implementation of composite services using workflow standards such as the Business Process Execution Language (BPEL). This new environment increases the capability of software vendors to provision components under Software as a Service (SaaS) and pay-per-use business models.

In parallel, the growing demands for mobile applications has led several industries to actively implementing solutions based on a wide array of handheld devices, Radio Frequency Identification (RFID), sensors networks, and wearable and embedded computers. While this trend was initiated primarily within closed wire-

¹ Université du Québec, Gatineau, QC, Canada, stephane.gagnon@uqo.ca.

² International Finance Corporation, Washington, DC, USA, kcakici@ifc.org
less networks, organizations everywhere are researching new ways to integrate these technologies seamlessly throughout and value chains.

Given the synergies between SOA and pervasive computing, we propose an assessment framework to integrate 2 converging technologies, namely Business Services Networks (BSN) and the Internet of Things (IoT), in order to facilitate the deployment of SaaS business models and SOA solutions.

In section 2, we briefly define these technologies and their synergies. In section 3, we present our proposed framework to help integrate them. We conclude with some benefits of the framework to develop SaaS business models.

2 Integrating Converging Technologies

A BSN is an IT infrastructure allowing a group of organizations to provision and consume their respective software components as services [1]. It is generally operated by a third-party IT service firm, offering a service governance lifecycle, a secure repository for services and identities, subscription and reuse policies, and Quality of Service (QoS) management.

As such, a BSN provides a more flexible and seamless integration of applications using various services formats, primarily relying on Web Services. They provide a logical evolution of the B2B integration infrastructure. In the same way the move from EDI to XML-based messaging solutions enabled more flexibility in formatting integration endpoints among trading partners, the move to SOA-enabled applications will bring greater architectural and runtime flexibility. BSN should therefore play a catalyst role in accelerating SOA and on demand software adoption [1; 2].

As for the IoT, it is a new paradigm for wireless and pervasive computing to seamlessly integrate various objects to the internet [3; 4]. These entities can be static (e.g., supplies, products, and equipments) or dynamic (e.g., people, animals, and vehicles), and can carry RFID tags and readers, sensors, or wearable devices.

While RFID features are more limited than other sensors, the decreasing costs of tags, readers, and software have led to their wide adoption. The simplicity of the technology is also a major factor. In particular, with a diversity of tag capabilities, there are numerous versatile applications in connecting lightweight things or objects to the internet.

Based on advances in materials science and electronics, RFID tags can embed high value features essential to various industries. These include detecting, classifying, and tracking mobile (sensor-less) objects in a surveillance field [5], monitoring the performance of electro-mechanical components [6], controlling manufacturing equipment [7-9], measuring ambient conditions through micro-biochemical reactions [10], monitoring the health of ill but autonomous patients [11; 12], etc.
Many potential benefits of RFID technologies remain to be explored and measured. As industry-wide standards are being developed, it is especially in the realm of B2B integration that untapped advantages remain strongest. In addition, integrating pervasive computing as a core element of software architecture is a challenge, as standard best practices are still emerging. It therefore opens the opportunity to integrate this approach with other key trends at the heart of information system architecture, namely SOA and SaaS.

Since integration issues are common to most distributed computing solutions, it has been proposed to help resolve them along with, and possibly as part of, the set of SOA standards that continue to emerge [13]. This is the first step in integrating BSN, the IoT, and SaaS environments. It would allow industry-wide configurations of RFID information and software as “services”, provisioned across B2B services networks, and possibly sold on a pay-per-use business model. It would also provide opportunities to apply SOA standards (e.g., Web Services Security) to overcome some of the most enduring challenges of RFID [14].

This integration may prove to be a major next step in the evolution of the Web. It would open the door to more complex, flexible, and adaptable information systems, whether at personal, business, or value chain levels. By combining the new BSN-IoT-SaaS environment with more intelligent systems, such as Multi-Agent Systems (MAS), organizations may also be able to develop truly autonomous solutions that consistently yield optimal results given surrounding events, constraints, and opportunities [9].

As the integration of SOA and RFID standards become a strategic research priority, new assessment frameworks may be required to properly identify, evaluate, and leverage mobile SaaS business models, such as:

- Provisioning Web Services with a utility computing, pay-per-use, metered, or on demand business model,
- Merging the components of several vendors into a WS-enabled Application Service Provider (ASP),
- Developing high-performance WS-enabled business processes (e.g., using BPEL) to provide end-to-end and on demand Business Process Outsourcing (BPO).

New SaaS offerings decompose applications into reusable end-points of valuable functionality (e.g., trade execution engine, client identity verification, credit rating algorithm, etc.). Vendors then conclude legal arrangements with upstream application services suppliers, which can be bound by Web Services or other standards. Once proper transaction control and billing mechanisms are in place, the application can be made available on the market, whether through a BSN, or independently through the web.

A framework for the integration of BSN’s and the IoT should therefore provide for a solid foundation to develop more open SOA and mobile SaaS solutions.
3 Assessment Framework

In order to properly integrate both business and technical issues, we take a transactional view of the relationships between these stakeholders. Therefore, we propose an assessment framework of BSN and their integration to IoT. It addresses the various issues along a typical transaction for SaaS components. The model addresses the following areas:

- Supplier Issues
- Market Issues
- Adopter Issues
- Delivery Issues

3.1 Supplier Issues

While we could arguably initiate a transactional analysis from either the supply or demand viewpoints, the emerging nature of BSN and IoT forces us to focus on SaaS vendors and other service suppliers as the starting point. Here are key questions that software vendors must address in evaluating whether to provision products using an on demand model:

1. **Inventory:** What software component, full applications, and automated processes are valuable to other companies and users, and marketable through SaaS-enabled grids?
2. **Re-Factoring:** How can the code and process be re-factored and SaaS-enabled so it can be commercially exposed on the market?
3. **Mining:** How can we identify in the company’s inventory those components and processes that meet stringent commercial and operational requirements for dynamically exposed end-points?
4. **Composition:** What SaaS standards and development tools are needed to build commercial-grade services, applications, and processes?
5. **Development:** How should we adjust development methods in order to blend application, software, market, and venture development methods?

3.2 Market Issues

The primary role of BSN is to create a market for suppliers and adopters of on demand software. When coupled with IoT mobile services, such networks can create more fluid and dynamic markets, with demand and supply available every-
where. As such, the next step in the transaction sequence is to address software services offerings, and how they are received on the market. Here are a number of issues that both BSN and IoT solution operators, as well as SaaS vendors, must take in consideration as they attempt to develop a market for on demand software:

6. **Publishing**: What new standards should be developed for the Semantic Grid to properly describe and publish the commercial features of new services, applications, and processes?

7. **Pricing**: How much should new offerings be priced, and what pricing mechanisms would ensure stability in provisioning these offerings?

8. **Marketing**: How should offerings be bundled, market segmented, and the sales process automated?

9. **Discovery**: What new standards should be developed to automate the discovery of commercial offerings, and their possible combination with non-commercial ones?

10. **Testing**: What framework could be used to allow the automated testing and validation of SaaS-enabled offerings by both suppliers and buyers?

3.3 **Adopter Issues**

In the early years of the market, the adoption of on demand software components, especially RFID-enabled, will be driven mostly by the relative need for business infrastructure connectivity. This will be increasingly the case in B2B supply chains, in order to help control the flow of goods and people across organizations. In addition, the decision to adopt BSN and IoT will be linked closely to the challenge of rapidly decreasing IT budgets, and the need for more flexibility in sourcing applications, which SaaS will provide in great part. Therefore, any assessment from the adopter perspective must first take into account the business issues in IT, as opposed to simply addressing technical challenges. Here is a sample of issues that surface from this perspective:

11. **Benchmarking**: How can a company benchmark its applications and identify the need for adopting externally-delivered SaaS-enabled components, applications, or processes?

12. **Evaluation**: What economic and decision models should be used to evaluate the offerings of various SaaS vendors and determine which one meets business and operational requirements?

13. **Contracting**: How can service, application, and process adoption be facilitated through automated negotiation, contracting, licensing, authorization, and configuration?
14. **Payment:** How should the delivery of SaaS-enabled solutions be charged to buyers, and what new business and financing models could supplier devise to ensure a strong and stable market for SaaS vendors?

15. **Integration:** How should adopting companies prepare their internal applications for the risky phase of integrating and deploying new SaaS-enabled solutions supplied by SaaS vendors?

### 3.4 Delivery Issues

SaaS vendors operate in a more stringent Quality of Service (QoS) environment than traditional ASPs. With the increasing interoperability of RFID technology, it is likely that SaaS over a BSN involving IoT will face a continuously improving QoS. As they sell components as opposed to fully packaged functionality, SaaS vendors may increase risk, transaction costs, security issues, etc. We synthesize here a number of issues deduced from these trends:

16. **Delivery:** What new standards should be developed on top of existing grid computing infrastructure to ensure the flexible and rapid development of networks for the commercialization of SaaS-enabled solutions?

17. **Security:** How should SaaS-related security standards be adjusted to take into account the business transaction features of commercialized SaaS-enabled solutions?

18. **Balancing:** How will commercially-exposed SaaS-enabled solutions perform as along with their traditional workload, and to what extent can there be a market for excess capacity to balance market workloads?

19. **Monitoring:** How should enterprise application management methods and tools be adjusted to take into account the monitoring of both operations and commercial issues in the transacting and delivery of SaaS-enabled solutions?

20. **Compliance:** How should real-time monitoring be adjusted to allow more efficient and effective regulatory compliance, as well as reduce the risks associated with the commercialization of SaaS-enabled solutions?

### 3.5 Extension of the Framework

Overall, these perspectives compete with one another much in the same way as do traditional stakeholders of third-party IT networks such as EDI, e-marketplaces, B2B integration hubs, etc. It will be necessary for BSN and IoT research to take a closer look at this previous literature and come to identify lessons by comparing major operators and adopters with prior similar experiences.
It is also likely that the scope of technical and business issues, and their interfacing, should converge into a set of core strategic issues that merge the interests of several stakeholders. Such issues as BSN security, IoT systems interoperability, automatic discovery, legal frameworks, or performance metrics are surely in the common interests of all parties involved and can also easily be tied to neutrally developed industry standards. While SOA standards will continue to present valuable opportunities to resolve these issues (especially security and privacy), more complex B2B collaboration challenges will also need to be addressed.

4 Conclusion

This paper has explored synergies between 2 major converging technologies, namely BSNs and the IoT. While both technical and business issues are being addressed by industry in each of these areas, there are tremendous opportunities to develop new standards and architectures that will help jointly resolve these issues, and thereby create a more integrated, seamless, and adaptable IT environment.

To provide guidance for this innovative strategy, we have proposed a new assessment framework to help design BSNs that integrate properly with IoT and mobile SaaS. We have focused on 20 key issues grouped under 4 key areas, namely supplier, market, adopter, and delivery. The importance of RFID technologies for each of these issues has been emphasized, offering the possibility to assess the potential of integration between BSN and IoT environments. Finally, we have positioned SaaS at the core of this new framework, with a concern for developing new business models in commercializing information, software, and computing services.

By applying this new assessment framework, SaaS stakeholders may be better prepared to leverage the BSN-IoT environment for renewed success. One key benefit will be to allow services to interact with objects anywhere at anytime, given proper security and policies. This will create numerous new opportunities for pay-per-use transactions, which could help many unprofitable SaaS models to become viable.

As well, while SOA is proving effective in integrating and optimizing business processes, a BSN-IoT environment may radically increase operational performance. It will allow even more flexibility in composing SaaS-enabled processes in real-time, as RFID functionalities trigger these services and processes.

Finally, once key industries have developed the necessary information sharing standards and agreements, and combined with new Artificial Intelligence capabilities, they could create the necessary foundations for “autonomous service innovation”. Throughout the IoT enabled by BSNs, SaaS-bearing devices and entities could activate their collective intelligence to autonomously compose innovative IT solutions. In addition, by compiling performance data and identifying operational patterns, these new services may be independently learned and further optimized.
by the learning-enabled IT infrastructure that provisions and monitors services for these solutions.

While these opportunities are yet to be demonstrated, BSN, IoT, and mobile SaaS environments have reached sufficient momentum to warrant further research and investment in creating these new business models.

References