CABA's Intelligent & Integrated Buildings Council (IIBC) White Paper Sub-Committee

The Impact of Cloud Computing on the Development of Intelligent Buildings

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Casey Talon

Senior Analyst, IDC Energy Insights

IIBC White Papers Background

The Continental Automated Buildings Association (CABA) is an industry association dedicated to the advancement of intelligent homes and intelligent buildings technologies. CABA is an international trade association, with over 300 major private and public technology companies committed to research and development within the intelligent buildings and connected home sector. Association members are involved in the design, manufacture, installation and retailing of products for home and building automation. CABA is a leader in initiating and developing cross-industry collaboration through various councils, research and member services.

The CABA Intelligent & Integrated Buildings Council (IIBC) works to strengthen the large building automation industry through innovative technology-driven research projects. The Council was established in 2001 by CABA to specifically review opportunities, take strategic action and monitor initiatives that relate to integrated systems and automation in the large building sector. The Council's projects promote the next generation of intelligent building technologies and incorporate a holistic approach that optimizes building performance and savings.

In 2012, it was decided that the IIBC would form a sub-committee in conjunction with CABA to coordinate the development, member participation, production and dissemination of white papers for the IIBC. The purpose of the IIBC White Papers Sub-Committee is to evaluate and recommend any new initiatives and activities the IIBC and sub-committee members believe the IIBC should undertake going forward. The focus is to identify and recommend relevant "hot button" issues and analysis in the Intelligent Buildings market for new “IIBC White Papers” - that would be of value to members and their organizations. The sub-committee currently consists of over twenty member participants who serve on White Paper Working Groups, in conjunction with research consultancies and CABA project administration. The sub-committee is chaired by Kyle McNamara; Verizon Enterprise Solutions. All IIBC members are regularly surveyed for new white paper topics, or can suggest new topics at any time. The IIBC White Paper Sub-Committee then selects the most viable topics for the development of new white papers, and volunteers to serve on individual white paper Working Groups.

The IIBC has agreed that all white papers produced by the IIBC White Papers Sub-Committee will be made available to the entire Intelligent Buildings industry via the CABA Research Library: **http://www.caba.org/research/public-research-library**. The sub-committee provides updates to the Council at regular IIBC meetings as to its progress – and to refresh and garner new white paper topics from the membership, to stay current of industry “hot button” topics.

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Executive Overview

Project Background

The Continental Automated Buildings Association (CABA) is a not-for-profit industry association dedicated to the advancement of intelligent home and intelligent buildings technologies. The organization is supported by an international membership of more than 300 organizations involved in the design, manufacture, installation, and retailing of products relating to home automation and building automation. Public organizations, including utilities and government organizations, are also members.

The Intelligent & Integrated Buildings Council (IIBC), a core working committee of the Continental Automated Buildings Association (CABA), undertook the initiative in 2012, to establish the "IIBC White Papers Sub-Committee. The purpose of the sub-committee is to garner member participation in the development and production of intelligent buildings industry white papers that are of particular interest to member organizations and the industry at-large. Sub-committee members, as well as the general IIBC, can suggest relevant "hot button" issues and topics for areas of exploration and white paper development. In conjunction with the IIBC, suggested white paper topics are approved and assigned to interested member participant working groups, within the IIBC White Papers Sub-Committee. Any IIBC member can join a particular working group and contribute to the development of any particular white paper – in conjunction with a research consultancy, academic institution or industry expert who volunteers to produce the final white paper.

"The Impact of Cloud Computing on the Development of Intelligent Buildings" white paper is the result of the collaborative efforts of the IIBC White Papers Sub-Committee "Cloud Computing Working Group". The working group was comprised of IIBC members and industry representatives from Verizon Enterprise Solutions, Siemens Industry, Inc., Priva Building Intelligence North America, CABA and IDC Energy Insights. Casey Talon, Senior Analyst at IDC Energy Insights acted as the research consultant on the white paper, putting together needs assessments and industry information from working group partners, to produce this white paper. The white paper assesses and promotes the next generation of intelligent building technologies, plus a whole-building approach that optimizes building performance and savings through the integration of enterprise cloud technology.

Key Areas of Focus

"The Impact of Cloud Computing on the Development of Intelligent Buildings" white paper working group developed the following areas of focus that they wished the white paper to address:

- To determine the value of leveraging cloud technology to provide energy management services to enterprises
- To determine where intelligent buildings participants should place their investments around cloud infrastructure for building energy management
- To determine the benefits, constraints, and risks of using cloud technology
- To get a sense of whether companies will adopt cloud-based energy management systems, or have them hosted in their own environments. To examine if companies will consent to allow their information to be used for benchmarking against other companies
- To gain insight into current market metrics, statics and the potential growth of cloud technology in the intelligent buildings sector
- To develop messaging to the market/customers on where cloud computing makes sense
- To develop a framework of for cloud technology for the BAS industry, to evolve BAS systems
- To compare the value of cloud based offerings vs. onsite installed
- To determine the value of cloud to provide solutions previously not (economically) possible
- To determine customer IT acceptance/preference of hosting BAS/BEM SW on the cloud vs. onsite
- To identify Customer's IT requirements

Given the extensive and detailed list of focus areas identified by the working group, attempts were made to address all. However, availability of information and time constraints were factors in obtaining sufficient information to address all areas of focus.

Proposed Research Framework

The research framework proposed to address the areas of focus involved the use of secondary and primary research methods.

- Secondary Research
    - IDC EI definition
    - Committee member refinement of definition & context
    - Submission of relevant information/data from working group participants
    - CABA research references – market reports, CABA Research Library

- Primary Research

    - End Users: Request 2 contacts (8 interviews total) from committee members per segment for 1 hour calls:
        - Hospitality
        - Healthcare
        - Retail
        - Higher Education
    - Vendor Input
        - Each Committee Member provides feedback to questionnaire below – can make anonymous if necessary (written email feedback for time savings)
        - CABA Member interviews? 3 ideal – possibly other members of IIBC?

Though the research framework proposed a very comprehensive and ambitious undertaking, there were significant limitations to the information collected and used for this white paper. The vast majority of the working group was unable to provide relevant reports and information, or pass along contacts for primary research interviews. As a result, **the majority of the white paper is secondary in nature** – with information from CABA, IDC and various submissions from working group members.

Summary of Findings

Cloud delivery of energy management solutions is a growing trend in the smart buildings marketplace. According to IDC, cloud services are: "Consumer and business products, services, and solutions delivered and consumed in real time over a network (most often, the Internet)." The convergence of information technology and building automation is delivering increasingly sophisticated smart building solutions to the market.

The IT architecture and reliance on analytics and data management that define these smart building solutions make cloud services an ideal fit. Facilities management has long been separated from information technology, so the question for the smart building industry is whether building operators and key decision makers are familiar and willing to invest in cloud based energy management solutions.

This white paper will give building management decision makers some perspective on the trend toward cloud delivery of smart building energy management solutions and key hurdles and opportunities around integrating these solutions.

Detailed Findings

Status of Smart Buildings

Investment in smart building solutions is growing across business segments and regions. There is variation in demand based on business drivers, new construction versus retrofits and business segments; however, there are expectations for significant growth in the industry in the near term.

The momentum in the market validates the assertion that the facilities management industry is undergoing a transformation, as information technology and building automation solutions combine to provide more sophisticated energy management capabilities. IDC Energy Insights has defined a smart building as a facility that utilizes advanced automation and integration to measure, monitor, control and optimize operations and maintenance. The key concept is optimization – that is, real time, automated adaptation to internal polices and external signals. The point at which a facility can truly be characterized as a smart building is when there is complete integration of automation and control technologies enabled across energy consuming and producing equipment. IT architecture along with analytics and data management are key deign components that enable this level of optimization.

There is a significant increase in the amount of data management and analytics necessary to manage the kind of holistic energy management strategy driving this transformation of a facility into a smart building. The amount and variety of data derived from smart building systems require sophisticated analytics and data management solutions, and this need is amplified as owners look to smart campuses and/or portfolios. Cloud based energy management becomes even more attractive as facilities mature into smart buildings and the requirement for sophistication in analytics and data management become more vital.

Role of Cloud Services in Developing Smart Buildings

Cloud based computing is a growing trend in information technology due to the benefits of lower first costs associated with servers and equipment and external support services to, in the building management space, enable advancing energy management capabilities.

Despite the straightforward definition of cloud services, there are elements of this delivery design that appears problematic to decision makers and can impact the adoption of cloud-based technologies. There is an assumption that end users require cloud-based solutions to be flexible, elastic, and granular. What does this mean for energy management in commercial, industrial and institutional facilities?

- **Interoperability**. As facilities are transformed into smart buildings there is a significant shift in the level of controls, instrumentation and data associated with these systems. Furthermore, even in facilities with existing building energy management/automation systems, there will be a variety of control systems and related data formats. Cloud-based energy management solutions could provide open platform design capable of integrating data from these disparate systems with a level of granularity necessary to support the kind of holistic energy management strategies which drive smart building investment.

- **Scalability**. Cloud-based energy management solutions are marketed as flexible technologies capable of scaling as more data becomes available with the integration of smart building technologies over a growing array of building equipment. This kind of scalability reflects the elastic resource scaling.

- **Value**. Cloud-based smart building energy management solutions also utilize the elastic use based pricing models that generate interest from end users that have limited budgets and finite resources.

Table 1 highlights how critical attributes of cloud services can be applied to cloud-based smart building energy management solutions:

TABLE 1

Cloud Computing Critical Attributes and the Development of Smart Buildings

Shared, standard service	An evolution of roles and responsibilities is inherent in the transformation of a facility into a smart building due to the convergence of IT and building automation in the enabling technologies. As a result cloud-based smart building energy management solutions can serve this variety of decision makers across the enterprise cost effectively.
Solution packaged	A holistic energy management strategy should help define the process of developing a smart building, and ease of integration is critical to successful technology utilization.
Self-service	Effective cloud-based energy management solutions are designed to be used via a web-interface that clearly illustrates the energy use data associated with the control and automation systems directing the changes in equipment operations.
Elastic resource scaling	The transformation of a facility into a smart building requires integrating control and automation systems over a variety of building equipment. The process plays out through multiple investments and cloud-based energy management solutions must be able to scale up as the smart building technologies come online.

TABLE 1

Cloud Computing Critical Attributes and the Development of Smart Buildings

Shared, standard service	An evolution of roles and responsibilities is inherent in the transformation of a facility into a smart building due to the convergence of IT and building automation in the enabling technologies. As a result cloud-based smart building energy management solutions can serve this variety of decision makers across the enterprise cost effectively.
Elastic, use-based pricing	Flexible and use based pricing models are central characteristics of cloud-based smart building energy management solutions.
Ubiquitous (authorized network access)	The cloud-based energy management solutions are by and large accessible via the Internet.
Standard UI technologies	Cloud-based smart building energy management solutions utilize standard user interface technologies
Published service interface/API	The ability to combine services and leverage diverse data is central to the viability of cloud-based energy management solutions in the smart buildings market based on the definition of smart building analytics and data management, which requires the solution to utilize and communicate data delivered in desperate formats.

Source: IDC Energy Insights, 2012

IT Perspectives on Cloud Services

The transformation of the facilities management industry underway suggests a shift in decision-making roles for business executives. As IT becomes more involved in the investment and operations decisions associated with facilities management, the opportunity to utilize more intelligent, IT-enabled smart building solutions grows. The growing acceptance of cloud services underscores some opportunities and challenges for cloud services in building energy management:

- **Need for education** - End users need education on the ways in which cloud-based smart building energy management solutions address security, uptime and reliability concerns.

- **Industry adoption** - As with other smart building technologies, there is variation in likely adoption rates based on business segment. Executives from the verticals that are more broadly adoption cloud computing solutions may be more open to and willing to invest in cloud-based smart building energy management solutions.

- **Smart building maturity** - The maturity of a particular enterprise's smart building development strategy may signal opportunity for investment in cloud- based solutions. If the enterprise decision makers have developed an investment strategy for investing in and integrating smart building automation and control solutions they will be requiring more sophisticated analytics and data management to fully realize the benefits of these investments. This need is further amplified when building owners are looking to manage smart building campuses or portfolios. The need to manage a growing number of smart building systems can strengthen the value proposition for cloud-based energy management solutions.

- **Resources constraints**. Cloud-based energy management solutions can also be beneficial for businesses/organizations that are lean on IT resources but developing holistic energy management strategies. Strong service models combined with low first cost impacts of cloud based energy management solutions can be attractive to resource constrained end users.

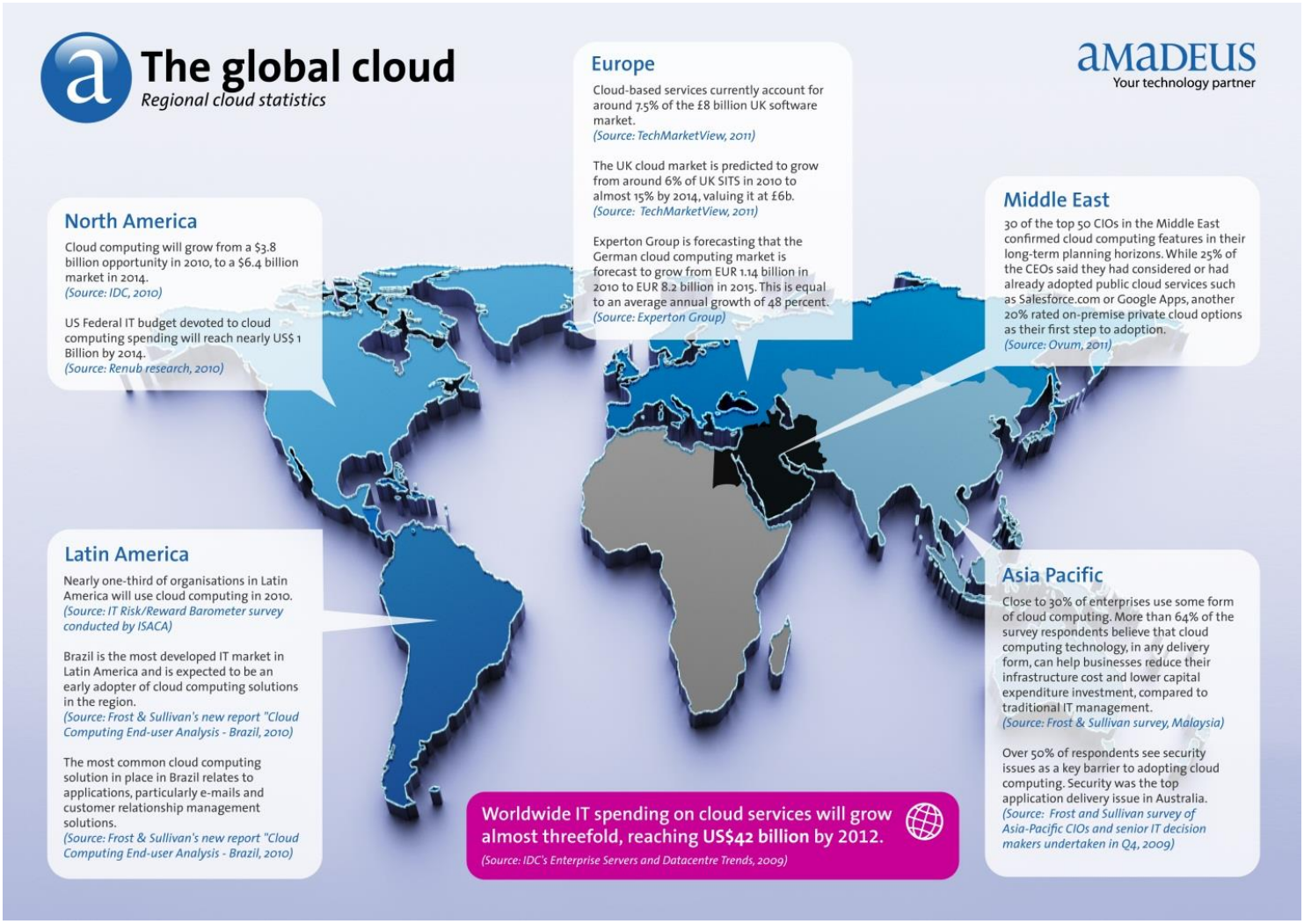
Conclusions

Business executives are investing in smart building technologies to manage energy costs, streamline operations and maintenance, differentiate their facilities, achieve sustainability and corporate social responsibility goals, and comply with new building codes and efficiency mandates. Cloud-based energy management solutions are emerging as a valuable delivery model to manage upfront costs and overcome resource constraints. There is an expectation that cloud based energy management solutions will become more widely adopted as decision-makers become more familiar with the benefits of smart building analytics and data management and deploying truly holistic energy management strategies.

APPENDIX A

Select Market Statistics, Links and Articles – Cloud Computing and Intelligent Buildings

Global Cloud Computing – Adoption and Projected Growth



The global cloud computing market will grow from $40.7 billion in 2011 to more than $241 billion in 2020, according to new Forrester forecast data reported in Sizing The Cloud by Stefan Ried, Ph.D. and Holger Kisker, Ph.D.

Roundup of Cloud Computing Forecasts and Market Estimates, 2012

Louis Columbus, January 17, 2012
http://softwarestrategiesblog.com/2012/01/17/roundup-of-cloud-computing-forecasts-and-market-estimates-2012/

The latest round of cloud computing forecasts released by Cisco, Deloitte, IDC, Forrester, Gartner, The 451 Group and others show how rapidly cloud computing's adoption in enterprises is happening. The better forecasts quantify just how and where adoption is and isn't occurring and why.

Overall, this year's forecasts have taken into account enterprise constraints more realistically than prior years, yielding a more reasonable set of market estimates. There still is much hype surrounding cloud computing forecasts as can be seen from some of the huge growth rates and market size estimates. With the direction of forecasting by vertical market and process area however, constraints are making the market estimates more realistic.
I've summarized the links below for your reference:

- **According to IDC, by 2015, about 24% of all new business software purchases will be of service-enabled software with SaaS delivery being 13.1% of worldwide software spending.** IDC further predicts that 14.4% of applications spending will be SaaS-based in the same time period. Source: http://www.idc.com/getdoc.jsp?containerId=232239

- **Mobile SaaS Market will reach $1.2 billion in 2011 and grow to $3.7 billion by 2016, with a five-year compound growth rate (CAGR) of 25.8 percent.** The ability to integrate business applications on smartphones, tablets and other wireless devices is predicted to accelerate SaaS adoption in the corporate business environment. Source: http://www.analytics-magazine.org/special-articles/454-corporate-mobile-software-as-a-service-forecast-

- **The cloud computing marketplace will reach $16.7B in revenue by 2013, according to a new report from the 451 Market Monitor, a market-sizing and forecasting service from The 451 Group.** Including the large and well-established software-as-a-service (SaaS) category, cloud computing will grow from revenue of $8.7B 2010 to $16.7B in 2013, a compound annual growth rate (CAGR) of 24%. https://451research.com/

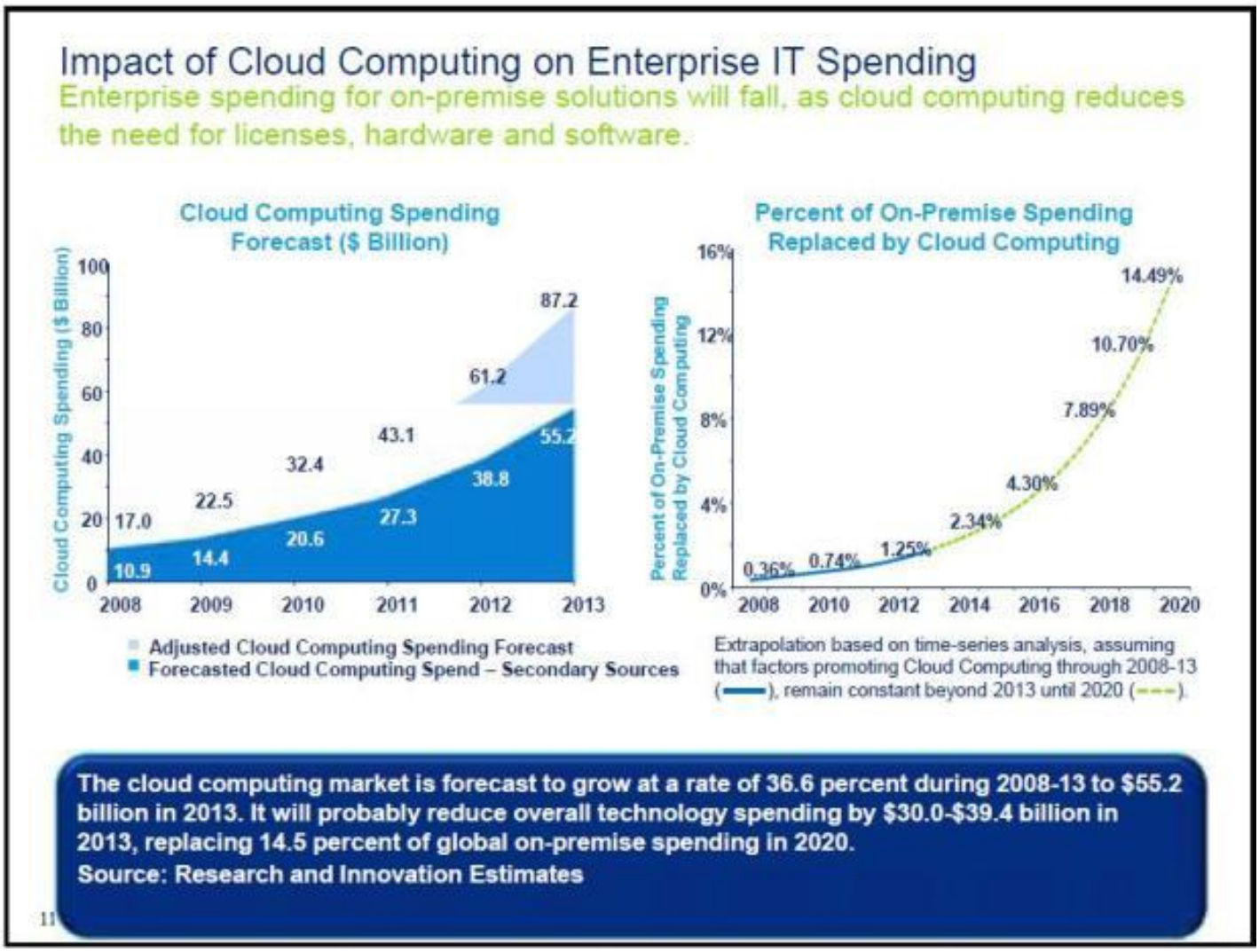
- **The US cloud computing market for medical imagery was at $56.5M in 2010 and is forecast to grow at a Compounded Annual Growth Rate (CAGR) of 27% during 2010-2018.** Link: http://www.medicaldevice-network.com/features/featuresnapshot-the-us-cloud-computing-market-for-medical-imaging/

- **The U.S. Federal Government cloud computing market enters into double-digit growth phase – at about 16% CAGR over the period 2013-2018, with annual federal cloud computing market to hit $10 billion landmark by 2018.** Link:

http://www.marketresearchmedia.com/2009/05/20/us-federal-cloud-computing-market-forecast-2010-2015/

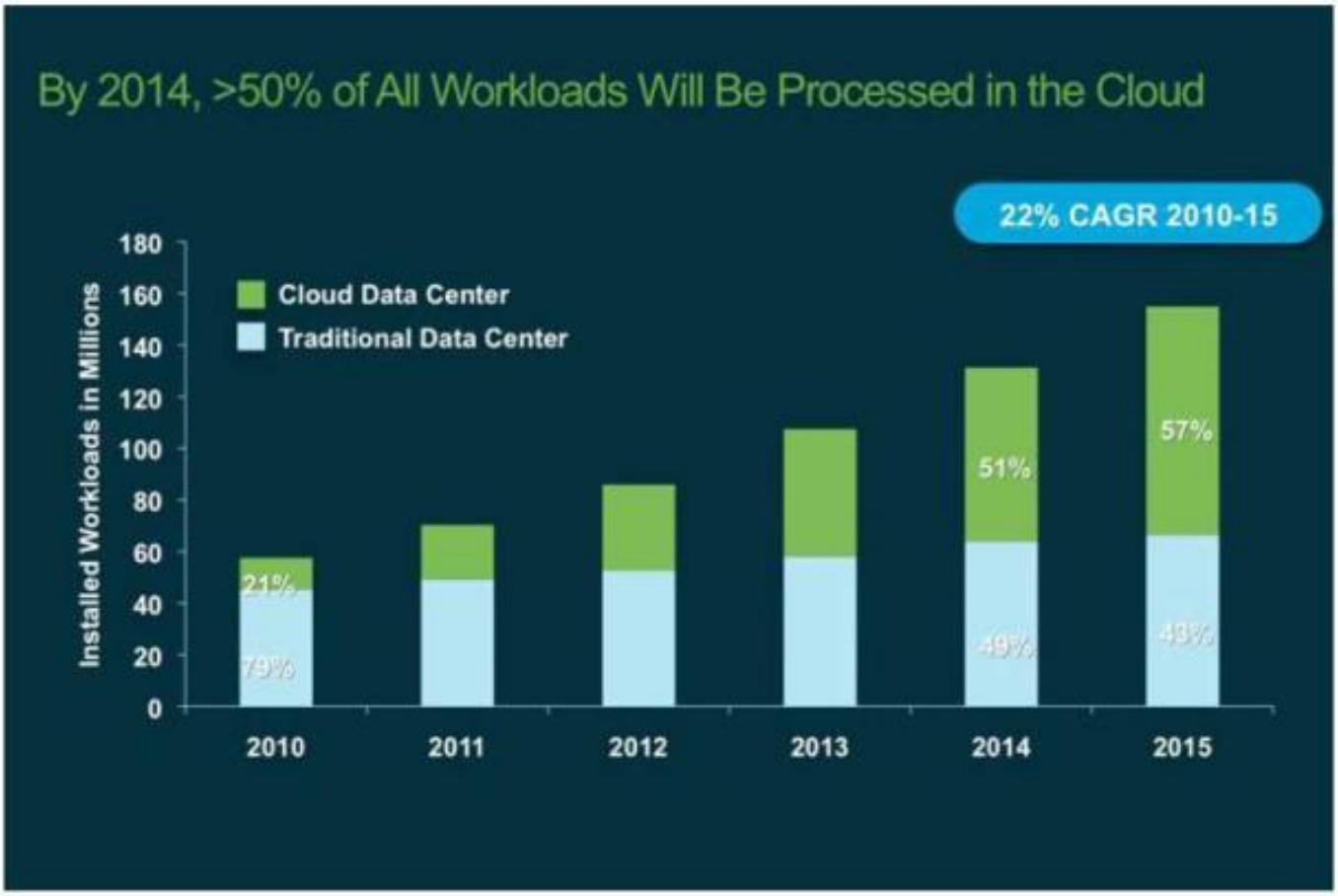
- **Forrester forecasts that the global market for cloud computing will grow from $40.7 billion in 2011 to more than $241 billion in 2020.** The total size of the public cloud market will grow from $25.5 billion in 2011 to $159.3 billion in 2020. Link to report excerpt is here.

- **Deloitte is predicting cloud-based applications will replace 2.34% of enterprise IT spending in 2014 rising 14.49% in 2020.** The slide below is from an excellent presentation by Deloitte titled Cloud Computing Forecast Change downloadable from this link.



- **Cisco predicts that Global cloud IP traffic will increase twelvefold over the next 5 years, accounting for more than one-third (34 percent) of total data center traffic by 2015.** Source: Cisco Global Cloud Index: Forecast and Methodology, 2010–2015. The following graphic is from the analysis:

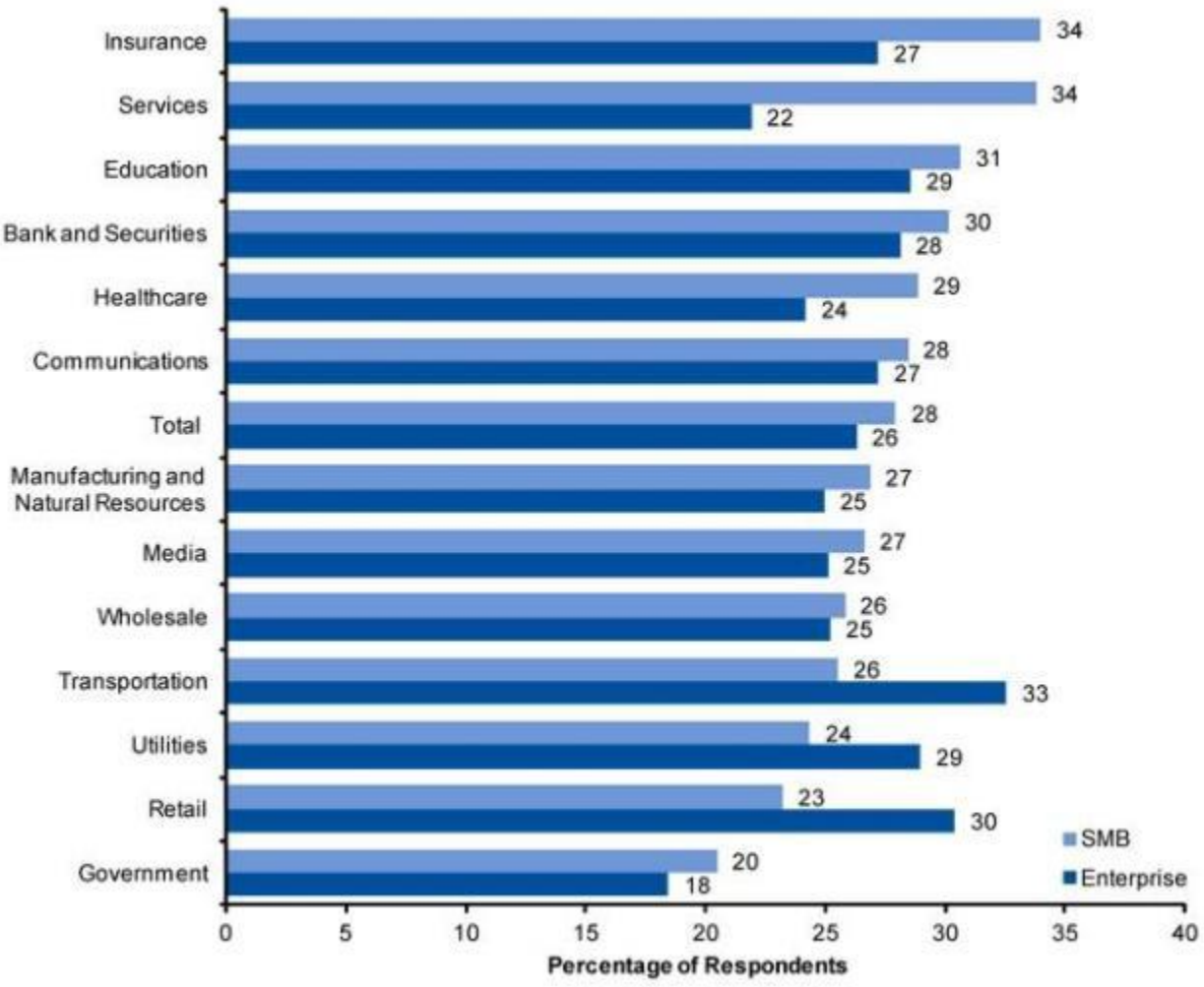
Figure 3. Workload Distribution: 2010 2015



Source: Independent Analyst Shipment Data, Cisco Analysis

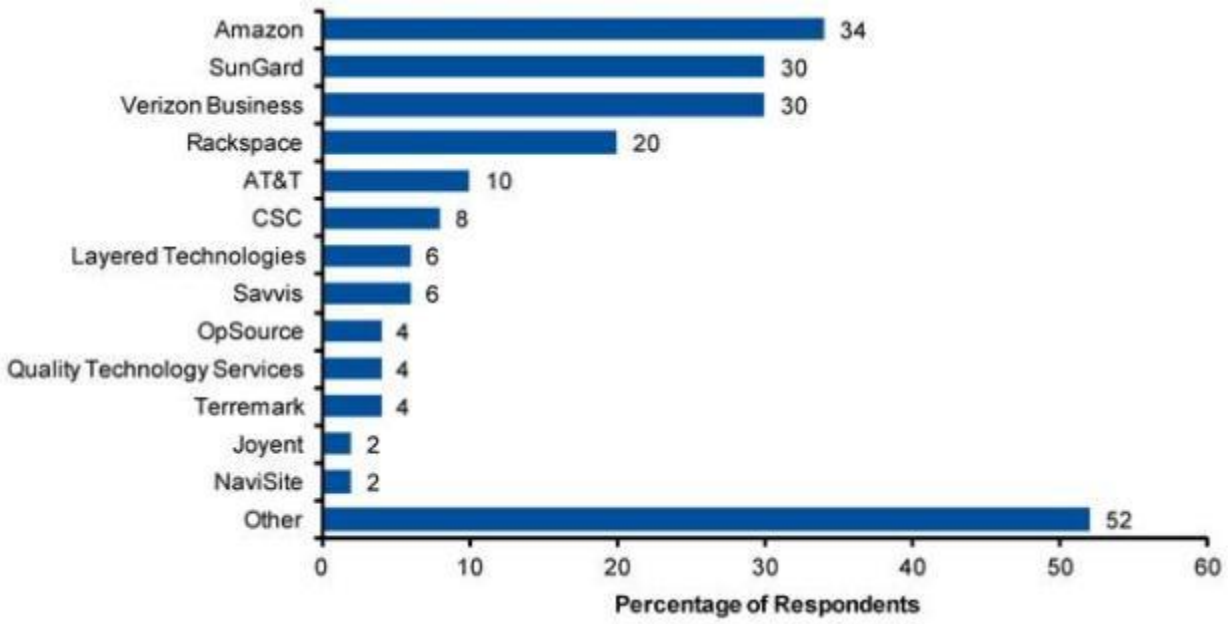
- **Gartner predicts Small & Medium Business (SMB) in the insurance industry will have a higher rate of cloud adoption (34%) compared to their enterprise counterparts (27%).** Gartner cites that insurance industry's opportunity to significant improve core process areas through the use of technology. The following figure from the report, 2011 SMB Versus Enterprise Software Budget Allocation to Annual Subscriptions indicates the differences in software budget allocation for annual subscriptions by vertical market from the report:

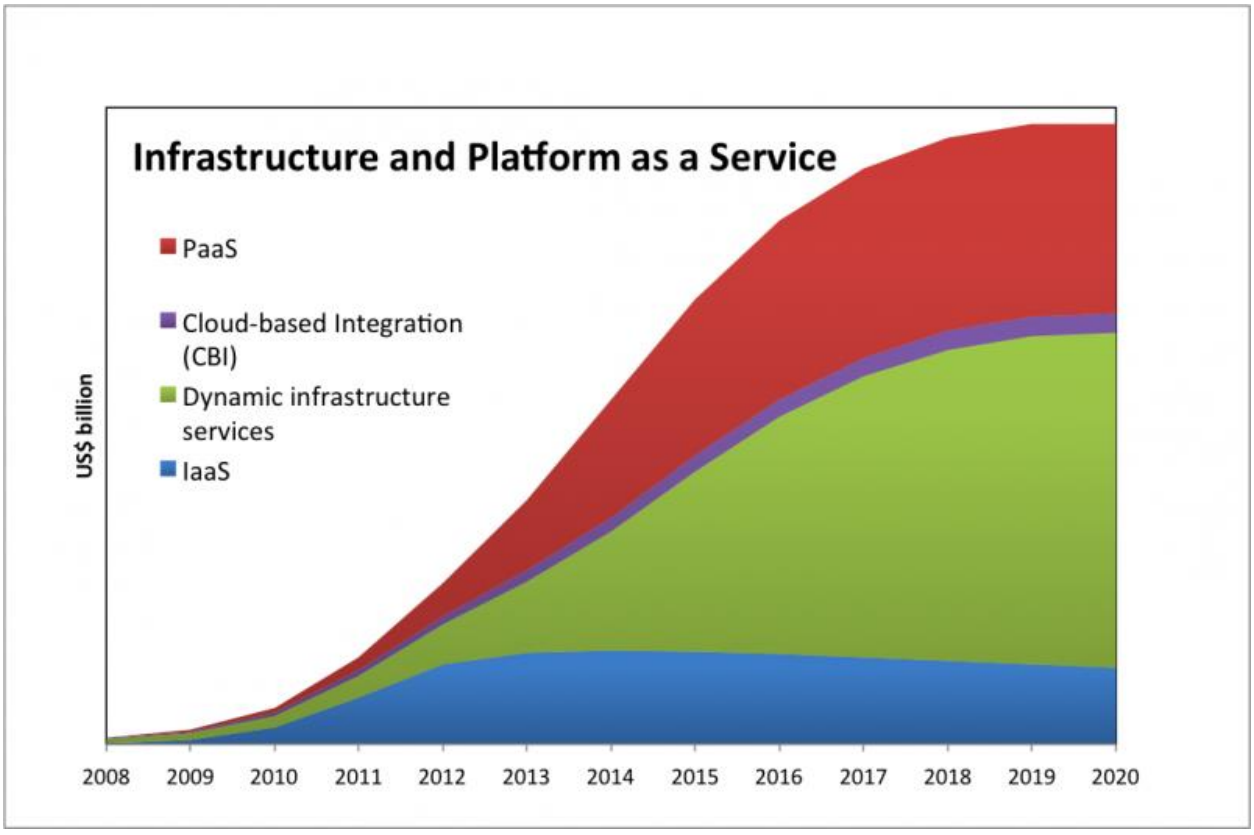
2011 SMB versus Enterprise Software Budget Allocation to Annual Subscriptions

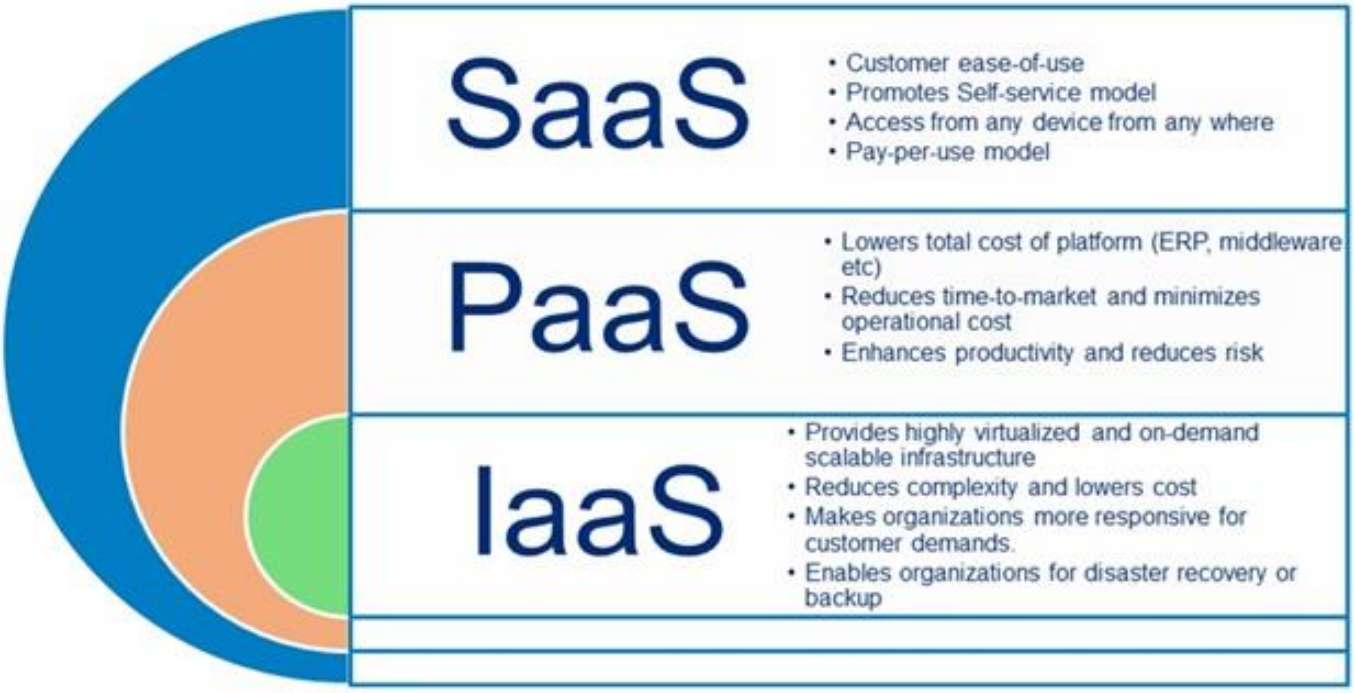


- **Gartner is predicting that the cloud system infrastructure (cloud IaaS) market to grow by 47.8% through 2015.** The research firm advises outsourcers not moving in that direction that consolidation and cannibalization will occur in the 2013 – 2014 timeframe. The providers named most often by respondents were Amazon (34%), SunGard (30%) and Verizon Business (30%). Of the global top 10 IT outsourcing market leaders, only CSC appears on the list. Source: User Survey Analysis: Infrastructure as a Service, the 2011 Uptake Claudio Da Rold, Allie Young.

External Service Providers Being Considered for IaaS (or Cloud IaaS)






SaaS
• Customer ease-of-use
• Promotes Self-service model
• Access from any device from any where
• Pay-per-use model
PaaS
• Lowers total cost of platform (ERP, middleware etc)
• Reduces time-to-market and minimizes operational cost
• Enhances productivity and reduces risk
IaaS
• Provides highly virtualized and on-demand scalable infrastructure
• Reduces complexity and lowers cost
• Makes organizations more responsive for customer demands.
• Enables organizations for disaster recovery or backup

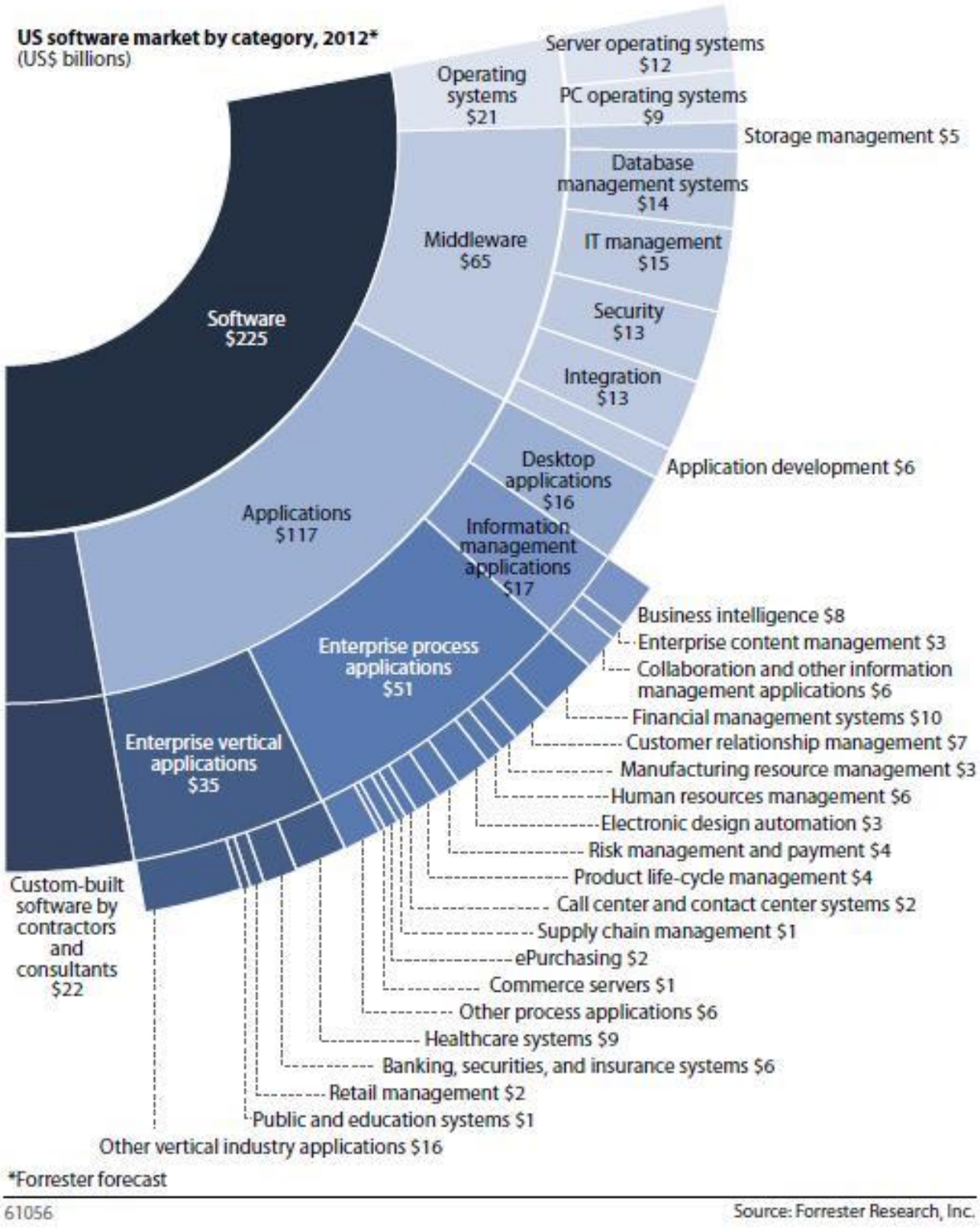
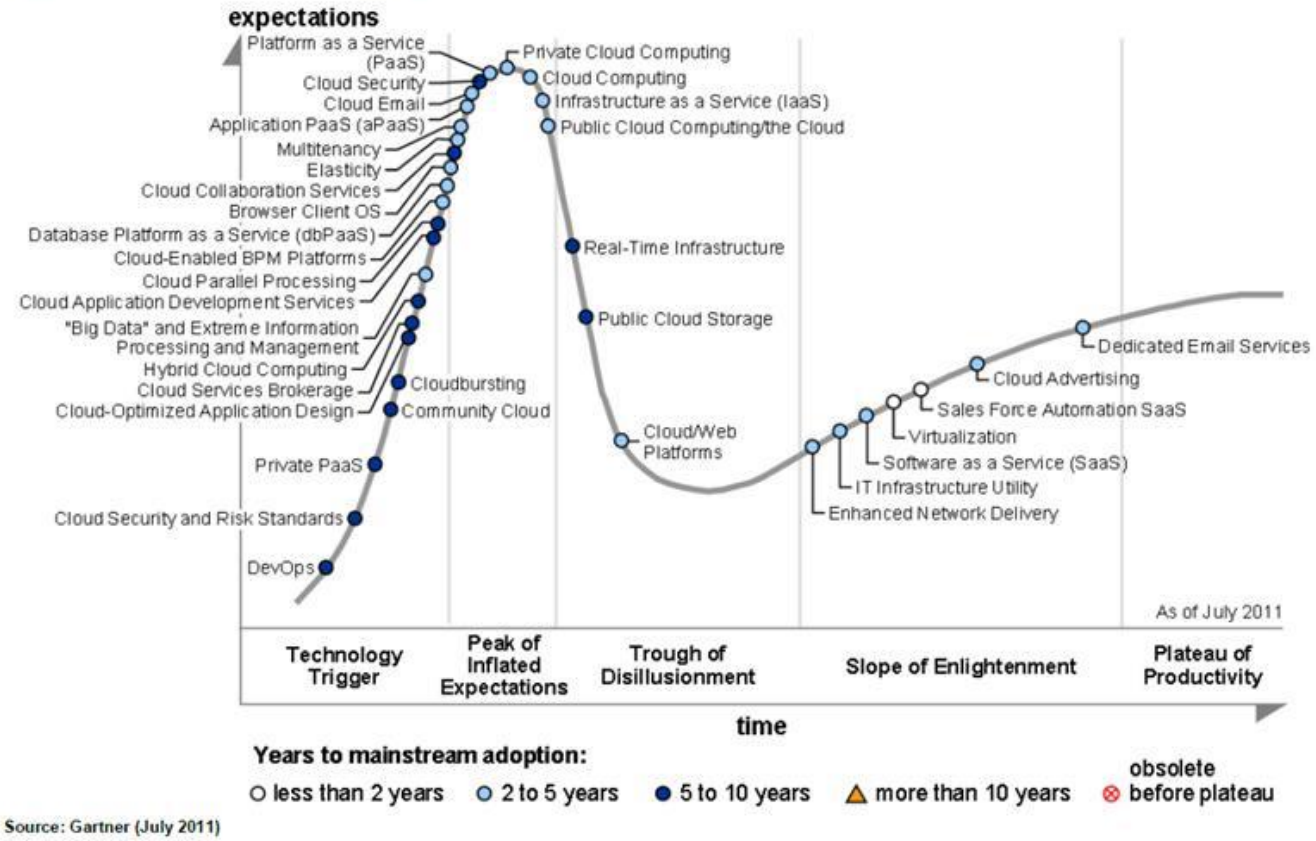

US software market by category, 2012*
(US$ billions)
Software $225
Operating systems $21
Middleware $65
Applications $117
Server operating systems $12
PC operating systems $9
Storage management $5
Database management systems $14
IT management $15
Security $13
Integration $13
Application development $6
Desktop applications $16
Information management applications $17
Enterprise process applications $51
Enterprise vertical applications $35
Custom-built software by contractors and consultants $22
Business intelligence $8
Enterprise content management $3
Collaboration and other information management applications $6
Financial management systems $10
Customer relationship management $7
Manufacturing resource management $3
Human resources management $6
Electronic design automation $3
Risk management and payment $4
Product life-cycle management $4
Call center and contact center systems $2
Supply chain management $1
ePurchasing $2
Commerce servers $1
Other process applications $6
Healthcare systems $9
Banking, securities, and insurance systems $6
Retail management $2
Public and education systems $1
Other vertical industry applications $16
*Forrester forecast
61056
Source: Forrester Research, Inc.

Figure 1. Hype Cycle for Cloud Computing, 2011



Source: Gartner (July 2011)

"Cloud Computing Statistics and Predictions for 2012"
SSD Cloud Computing News and Industry Blog – May, 2012

http://www.cloudproviderusa.com/cloud-computing-statistics-and-predictions-for-2012/
http://www.gartner.com/technology/research/predicts/

In December 2011, Gartner and IDC released their latest cloud computing (and Big Data) statistics and predictions for 2012 through 2016.

1. In 2012, 80% of new commercial enterprise apps will be deployed on cloud platforms - IDC.
2. By 2016, 40 percent of enterprises will make proof of independent security testing a precondition for using any type of cloud service - Gartner
3. At year-end 2016, more than 50 percent of Global 1,000 companies will have stored customer-sensitive data in the public cloud - Gartner

"Top 10 Cloud Computing Statistics"
Netmetix Industry Blog – November, 2012

http://netmetix.wordpress.com/2011/11/09/top-10-cloud-computing-statistics/

Netmetix cloud survey of small to large enterprises, 2012:

1. **Last year the snow caused staff shortages for 73% of companies and of these only 39% had the ability to work remotely.** Cloud computing is renowned for its ability to allow employees to access the business from any location in the world. This combats any weather related issues that could hinder business at any point in the year, providing there is an internet connection.
2. **The cloud computing market is expected to rise from $40.7 billion to $241 billion by 2020.** Depending on these figures, cloud computing could save 85 million tons in annual net CO_2 savings by the same year which shows the green effect it will have on the world.
3. **According to IBM's Chief Technology Officer, cloud computing reduces IT labour costs by 50%.** When a cloud system is implemented into a business, the majority of the IT responsibility is shifted across to the providers. Therefore all software updates and technical issues no longer have to be addressed individually.
4. **Cloud computing can save small business energy costs by 90%.** This is an increasingly popular incentive for businesses to adopt a cloud system. Not only does it reduce your company's carbon footprint, but you can also increase your CSR credentials.
5. **82% of small businesses say it's important to buy cloud computing from a company with local reach.** Customers are generally happier when they know their cloud provider is local. It adds the "human" element rather than dealing with a large faceless corporation that focuses on volume business rather than quality of service.
6. **58% agree that being on the cloud has given them better control of their data.** Being able to access your company's data and IT systems whenever and wherever you want means that you are always in control of what is happening in your business.
7. **41% of profit-focused small business owners plan to invest in the cloud by 2014.** It is evident that small businesses are recognizing the benefit of cloud computing as the uptake is constantly increasing. Companies are recognizing the value and benefit of Software as a Service and Infrastructure as a Service, which dispense with the need for expensive capital equipment and costly installation and upgrades of software.
8. **Industry use of Cloud Computing: Financial Services 63%, Manufacturing 62%, Healthcare 59%, Transportation 51%.** Four main industries are predominantly using cloud platforms already for their business. This illustrates the continuity in demand for such a system.

9. **50% agree that business agility is the primary reason for adopting cloud applications.** The fact that cloud offers elasticity and complete flexibility of service to company's means that business operations can be carried out far more efficiently.
10. **72% of organizations using private cloud servers have improved end-user experience.** Cloud creates a more productive and engaging working environment for employees, leading to higher levels of motivation and performance.

The Future of Cloud Connectivity for BAS

Nirosha Munasinghe MBusIT BSc BE (Hons) (Melb)
Automated Buildings.com – Article – June 2010

http://www.automatedbuildings.com/news/jun10/articles/opengen/100524034303opengen.htm

It is clear that cloud computing has the potential for the BAS to seamlessly integrate with other business services to provide a user friendly, cost effective and in depth solution to the client, transparent of the underlying technology.

Cloud computing has the potential to be the next major driver of business innovation across all industries allowing more dynamic, resilient and cost effective information technology systems to organizations. Over the last few years the concept of cloud computing has gain widespread of interest in research institutions and businesses to debate the implications to formulate a path to use the technology as a business enabler to gain competitive advantages for organizations. However, as with any technology it is difficult to distinct the reality from the hype to form a clear strategy to capitalize on the technology. Just as many industries became a winner with high rewards with the dot com boom, there were many failures. Cloud computing will have a similar impact in the market place and it is up to the industry to define a winning strategy to successfully adopt the technology.

The building automation industry has generally been a slow player when adopting new technology. Over decade ago, majority of building automation systems were proprietary and the BAS was another tool required for operation of a building. A facility manager reacts to the system when in fault but system was non-existent to the outside world. However, over the decade emergence of open system protocols such as BACnet and LonWorks and worldwide emphasis on energy management and sustainability, the rate of adoption of new technology and rate of continual improvement by BMS vendors has increased dramatically. Most vendors are using web technology and open system architecture to integrate and converge with IT networks to create new features at a more cost effective and time efficient manner. As the cloud computing wave hits the market, it is up to the IT executives of the building management system vendors to adopt the technology into BAS with a clear strategy. The paper analyses the basic concepts of cloud computing, the implications it has n the BAS value chain in manufactures, system integrators and end user and an example to outline the operation of cloud in the BAS market.

Cloud computing is the term used to describe the use of interconnected business applications over the Internet. As depicted in figure 1, the applications are interconnected via web services and the end user accesses the required service using a web browser. Therefore the application and the infrastructure does not reside in end users premises. The end user accesses the

application on demand and can concentrate on using the application for its purpose, without investing in capital expenditure and avoiding the overhead of installation, networking and maintenance.

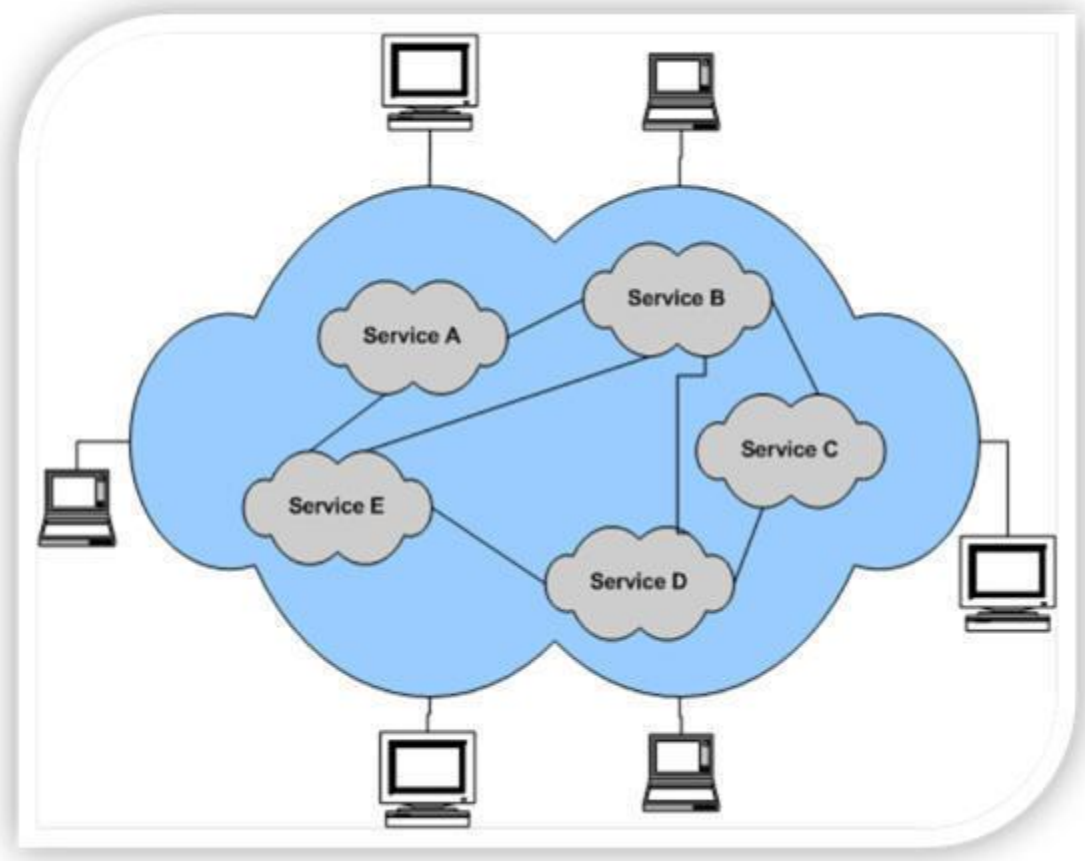


Figure 1: Set of interconnected business services/applications via web services, communicating with each other is available as a web service or via web browser over the internet for the end user.

Each service or cloud consists of detail architecture and technology invisible to the end user. It consists of the *application/service, platform, infrastructure and storage.*

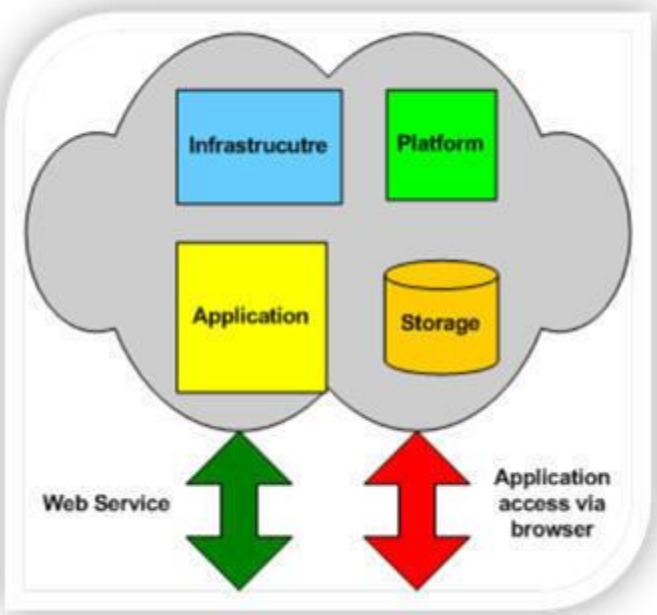


Figure 2: The detail technology behind the cloud

- **Application/Web Service:** Delivers the software/application as a service (SaaS) to end user or other clouds. For example the end user in BAS can access the user interface for control networks and it can have services for other parties obtain data from BAS.
- **Infrastructure:** Computer infrastructure usually in platform virtualization environment as a service.
- **Platform:** Allow developers/users extend or write new applications using the platform as a service (PaaS)
- **Storage:** Consists of the database to read and write data.

The early modeling of the cloud computing concept has various deployment methods in *public, private and hybrid* clouds. A public cloud service is available over the Internet via direct application or web service to the end user. A private cloud is restricted to private networks for data security and reliability. A hybrid cloud consists of multiple private and/or public clouds to provide enterprise solution. Which deployment model will the building automation market fit into? The vision of smart grid where the BAS communicates with other industries and the need of having a secure control network clearly indicate that BAS market will adopt a hybrid model.

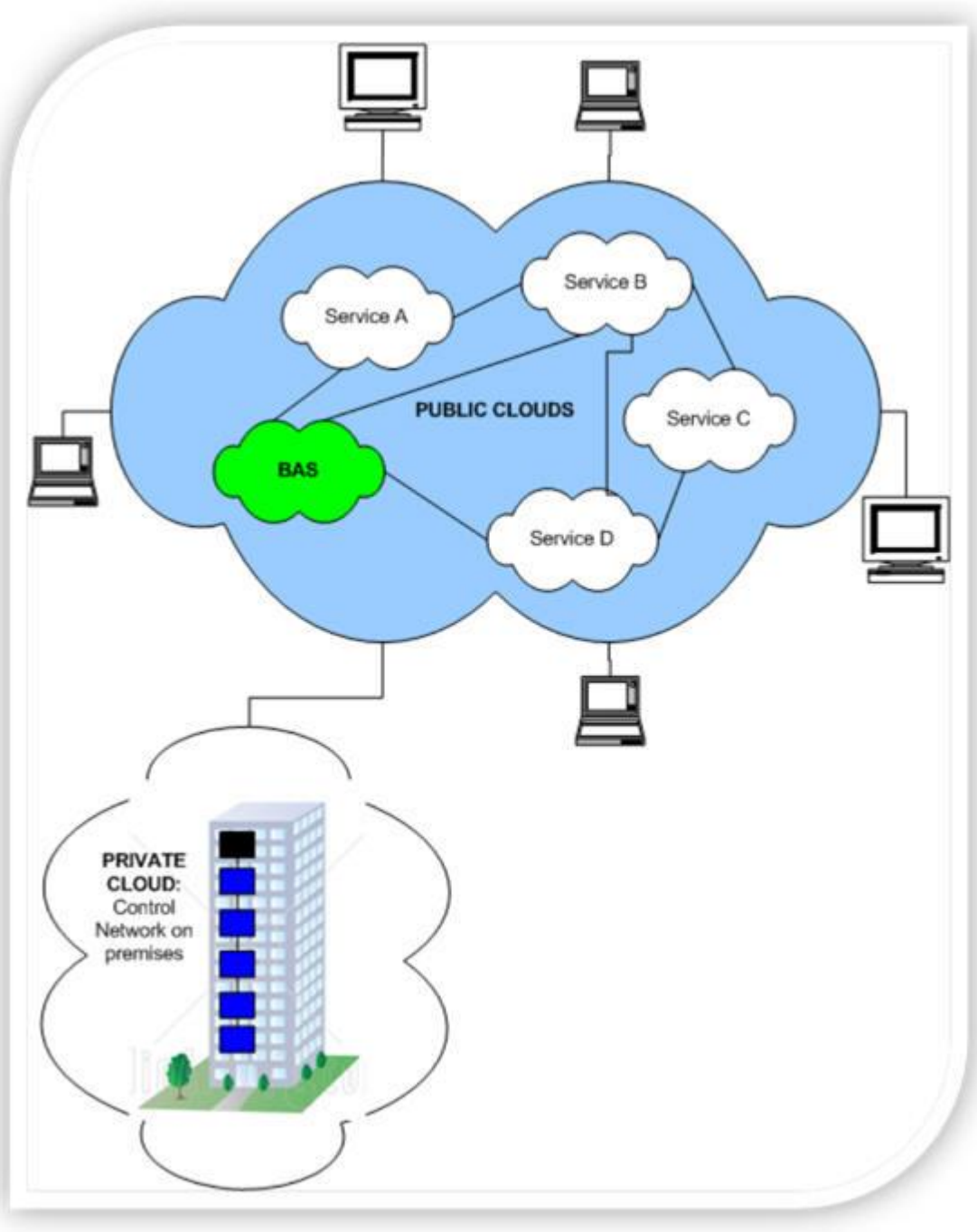


Figure 3: Hybrid Cloud Model for BAS

As it is depicted in the figure 3, the general cloud computing architecture for BAS includes the building management software residing in a public cloud interacting with the other clouds and the control network itself is in a private cloud in a building. Obviously the controls itself cannot be moved away from the premises and the control networks should be restricted to the stakeholders of the building. Therefore a hybrid cloud models the BAS market space.

What is the implication of the hybrid cloud computing model to the BAS value chain in manufacturers, system integrators and end users?

- **BAS Manufacturers**
  Cloud computing concepts must be driven by the BAS manufacturers. The manufacturers must begin to transform their current software applications into a fully web enabled architecture. The implication for the manufacturers is the investment in the R&D process to transform their existing products into a fully web enabled model. However, at present as most BAS vendors have some presence of web technology in their product range, the processes of transformation can be phased into manageable components. Latest web technology such as AJAX and Adobe Air can assist the developers in tackling common web issues such as speed and appearance. Also, the manufacturers need to open up their software via web services to integrate with other clouds in the network and extend features such as enabling platforms for users to further enhance the system to meet their requirements. One key challenge of exposing application program interface to external users is security. At present most BAS vendors has basic security features implemented in their systems. As the manufacturers transform into the web and cloud computing model, high investment must be allocated in developing data encryption layers for the application. Also, more robust solutions must be implemented as the application delivery architecture is a one-to-many model (single instance, multitenant architecture). This includes data backup and server switching on failure procedures. The primary benefit of cloud computing for the manufacturers is the ability to integrate with other businesses in the same or different industries to form business partnerships to form new business models to improve their competitive advantage.

- **System Integrators**
  The system integrators benefits from cloud computing from cost reduction in application support and more opportunity to integrate with other business services to provide turnkey solutions to the end customer. As the software is severed as a service (SaaS) to the end customer, less instances of the application is installed allowing the integrators to manage and support it from a single point of control. The integrators can use the platform as a service (PaaS) to further enhance the existing functionality of the software and integrate with other business services. The implication to system integrators includes space requirement to manage servers as it is moved away from the end customer and to have robust networks to support multi-tenant architecture. The integrators have the opportunity to maximize server usage by virtualizing it to maximize the throughput. At present if one server is installed per site, the server is not used to its capacity. In a cloud environment, the physical server can be virtualized to run multiple clients from one server.

  The Cloud computing architecture also creates more complexity to managing networks and integration, which requires system integrators to better educate their support staff to manage the issues. The cloud concept can be an immerse change to support staff who has been in BAS support role for many years. Over ten years ago, BAS had a simple dedicated network and some cases just stand alone devices. Therefore troubleshooting was independent of each device and simple. As BAS converges with the IT networks, web and cloud model integrating with many other applications, it is very important for the integrators to continually educate the support staff to avoid backlash of the technology to evolve the cloud concept in the BAS market.

The system integrators also require changes to their pricing models as the software and infrastructure is provided as a service to the end customer. The customer pays a subscription fee for the service rather than purchasing licenses. Therefore the integrators require remodeling of pricing structure and negotiate new service level agreements (SLA) to maximize their return.

- **End Users**
  The primary beneficiary of cloud computing architecture is the end customer. The facility managers can devote more time to enhancing the value of using the BAS by managing onsite mechanical and electrical assets and less on day to day challenges of networks and servers. The technology behind cloud computing is transparent to the user, making the cloud computing incredibly user friendly. The cloud concept greatly benefit multi-building/multi-national sites situated globally such as universities, department stores, fast food outlet chains, banks and hotels as few examples. In current situation, such sites have multiple servers taking up real-estate and databases with duplicate and redundant data. In a cloud environment, it can operate in one application instance and database accessed via the web browser from anywhere in the world. This yields significant cost savings in real estate, which translates into reduction in energy consumption for power and cooling costs of servers. The facility manager has access to global view of data collected from the control networks, which translates to better decision making process to improve issues such as energy management and carbon foot reduction. Also, as the capacity of the valid data increases, more opportunities arise to use the data as intelligence for BAS to provide proactive solutions to the challenges of managing a building.

To illustrate cloud computing model in action in the BAS market, let's examine a simple example case study of a global hotel's requirement of improving comfort level for its guests, reduction in energy consumption and carbon emission. The characteristics of the requirements as follows:

- Branches of the hotel situated globally with 100 plus branches
- Executives require summary data of energy, water and carbon consumptions
- Facility mangers at each location require detail usage data for comparison
- Require proactive actions to be taken to meet key performance indicators (KPI)
- Hotel has a Enterprise Resource Planning (ERP) software managing the financials
- Costs associated to with energy must be allocated to each branch

Current Environment

At present to meet such requirement the control networks is installed at each branch and at each location a server running the software with a database to monitor and control. Therefore it requires 100 plus servers, requiring a large investment in capital. For reporting requirements specialized software needs to written to merge the databases and link with the ERP system to allocate costs. It is difficult to proactively manage the KPIs as system can struggle to obtain the required data at the right time. The current systems have great difficulty to meet such requirements in efficient and cost effective manner.

Cloud Environment

In a cloud computing environment, the controls networks is installed at each branch and one instance of software with a database installed at one location, which saves real estate and power consumption. The executives and facility managers accesses the required data from web browser from their local destination. The general architecture as follows:

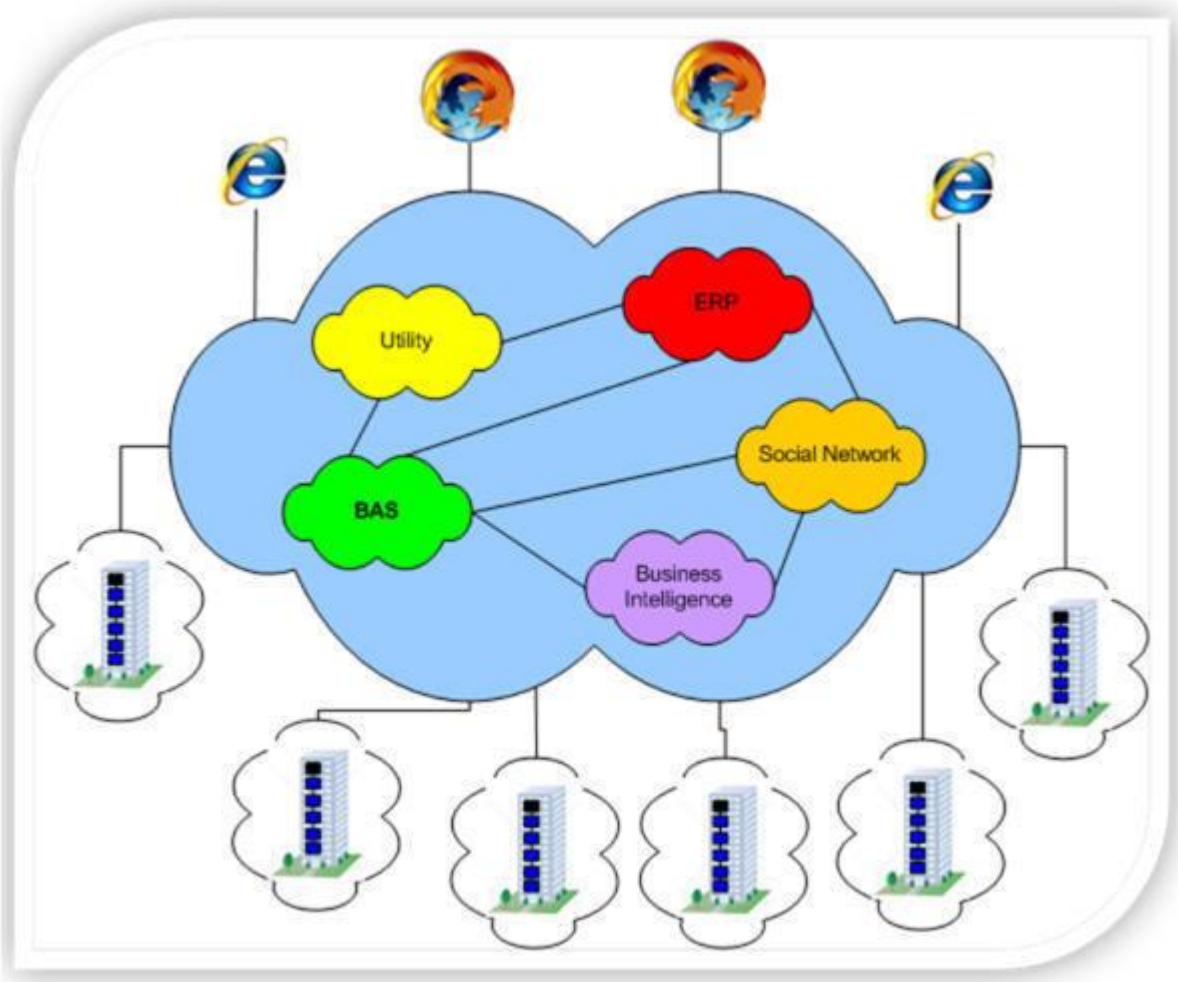


Figure 4: BAS connectivity to the cloud.

Figure 4 illustrates the control networks in a private cloud with the software application in a public cloud interfacing with other business services to provide a turnkey solution to the hotels requirements. The dynamics of the cloud as follows:

- The BAS interfaces with utility services to obtain real time data in power, water, gas consumption for each building for comparison against actual data obtain at each site via the control network for reporting
- The BAS interface with the ERP system's general ledger to allocate costs for each branches usage of energy
- The BAS interface with social networks such as Twitter and Facebook to inform the hotel's staff and customers about energy usage and carbon emission to encourage further savings

- The BAS is interfacing with business intelligence software, which generates custom reports required for executive, management and user levels. The data obtain from the BAS via control networks for each branch is linked to the intelligence software via web service to generate the reports. As more data is gathered by the intelligence software, it performance data mining to proactively report actions required to meet the key performance indicators. The facility managers can compare different branches performance and set benchmarks to improve on KPIs.
- The users access the end result of above integration using simple web browser.

From the simple example it is clear that cloud computing has the potential for the BAS to seamlessly integrate with other business services to provide a user friendly, cost effective and in depth solution to the client transparent of the underlining technology. The cloud computing model benefits BAS manufactures, system integrators and end customers to streamline their current business models and open up new ventures. However, the BAS industry must be proactive in developing strategies to manage the model change and not fall behind other industries during the transition period.

CABA Contacts

For more information regarding IIBC White Papers or how to participate please contact CABA for further information:

Contact

John Hall
CABA Research Director
1173 Cyrville Road, Suite 210
Ottawa, ON, K1J 7S6
Phone: 613.686.1814 x 227
Hall@CABA.org

George Grimes
CABA Business Development Manager
1173 Cyrville Road, Suite 210
Ottawa, ON, K1J 7S6
Phone: 613.686.1814 x 226
Grimes@CABA.org