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Has the Picture Archiving and Communication System (PACS) Become a Commodity?

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The Picture Archiving and Communication System (PACS) market has been transformed by disruptive innovations from the information technology industry. The cost of storage alone has dropped by a factor of 100 within the past 10 years. Improvements in display, processing, and networking have likewise enabled PACS to be a capable replacement for film. The maturity of PACS has permeated the US healthcare industry from large academic hospitals to small outpatient imaging centers. Can PACS continue to be a platform for innovation or has it become a commodity?

KEY WORDS: PACS, cost analysis, computer hardware

THE PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IS A COMMODITY: JAMES CHEN, MD

Opening Statement

The basic function of Picture Archiving and Communication System (PACS) can be distilled to storing, retrieving, and then displaying images. The first PACS were multimillion dollar systems, custom engineered for each customer. Due to their proprietary and custom nature, the high cost of early PACS prevented a positive return on investment. Since those initial systems, PACS has evolved into cheaper, standards-based systems with multiple vendors. The current return on investment is now positive and great enough[1] that groups or institutions without PACS are at a competitive disadvantage. Thankfully, PACS has become a commodity, making its benefits more accessible to its purchasers and their patients alike.

Previously, PACS vendors created at great expense custom chips and boards with tightly integrated software tweaks to overcome the limits of off-the-shelf hardware to store, transfer, and display high-resolution and high-contrast medical images. Following the relentless march of "Moore's Law,"[2] current commercial off-the-shelf hardware now performs at levels that obviate the need for expensive custom-designed hardware for PACS[3]. As a result, vendors can take advantage of this commodity hardware and their economies of scale to reduce design and hardware costs, and to reduce the cost to the consumer. Now, instead of being solely reserved for large institutions with large capital budgets, PACS is now more affordable and is diffusing further into more cost-conscious groups and smaller institutions previously unable to afford it.

Customers benefit from not just commoditization of the hardware but also the software and underlying protocols of PACS. The shift from proprietary vendor-specific protocols to standards-based software improves interoperability and vendor choices for the customer. Due to the adoption of standards such as Digital Imaging and Communications in Medicine (DICOM)[4], Health Level 7[5], and integration profiles from the Integrated Health Enterprise[6], purchasers can now concentrate on the best solution for their needs, instead of limiting themselves to solutions from a single vendor's product line. The adoption of standards and the improved interoperability of the various PACS software subsystems have been a boon in increasing

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customer choice, which will only increase as customers insist on the implementation of current and upcoming standards and integration profiles.

Once image receipt, storage, and transmission are complete, the next basic function of PACS is image display. The universally common functions and required basic image manipulation tools allows a radiologist to sit at any PACS workstation, sometimes with little or no additional training, to begin the task of image interpretation. Useful basic image processing and annotating tools such as window-level, measurement and annotation, and region of interest are present in all modern PACS, despite different implementations. When these basic required features are compared across vendors, it can be difficult to distinguish them. Consumers benefit by being able to expect similar functions across vendors and concentrating on choosing the implementations and workflows that fit their environments best.

As vendors struggle to differentiate themselves in using hardware and software, they have found it necessary to innovate with their business models. They must now be more responsive to customer needs, which can range from support services to feature requests and bug fixes to new licensing and purchasing models which better fit the client needs. As the initial PACS customers evaluate newer systems for upgrade and migration, vendors must align with their customers' needs or else face replacement with another vendor. This has lead to innovations in the PACS business model. Instead of solely offering high initial-outlay purchase contracts based on the number of boxes (servers, workstations, and storage), some vendors now offer concurrent running software licenses to even unlimited software licenses using revenue sharing as a percentage of each procedure performed. This maturation of the PACS market has led to further business model innovations that allow customers choose the pricing models that best fit their capital budgets.

Overall, the commoditization of PACS has been a boon to customers. It has decreased the cost of purchase, improved interoperability, eased replacement, increased choice in purchase and pricing models, and improved the vendors' response to their customers. This has increased the availability of this productivity-enhancing technology to areas of healthcare outside of those with the largest capital budgets, and significantly improved problems with inter-vendor interoperability. As the commoditization continues, it will only bring the benefits of PACS to more and more healthcare centers and the patients they serve.

THE PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IS NOT A COMMODITY: JOHN BRADSHAW, MD

Opening Statement

Products in a commodity market compete solely on price, not any other differentiating features[7]. A classic example of a commodity is oil. Oil is oil—it's the same whether it's from Venezuela or Saudi Arabia. All anyone cares about is the price per barrel. Compare that with wine where price per bottle ranges dramatically and consumer selection is based on a myriad of features besides price.

When you say PACS is a commodity, you are saying in effect that the CIO and CFO should select a vendor purely on price. Purchasing a PACS system is a complex decision and influenced by the perspectives from end users, technical staff, and management. From these various perspectives, the significant differences between current products' architecture, usability, and degree of interoperability provide a basis for feature-based competition in the PACS market and a platform for future innovation.

Usability

In my clinical practice as a radiologist, I have used PACS systems from four different vendors. Even with basic and frequently used features such as window/level adjustment and stack navigation, there is no standardization. Most use *X* and *Y* axis movements of the mouse to change window/level settings, but neither the axis nor direction of movement is the same. One uses the right mouse button, another requires selecting a tool from a toolbar or menu, the third uses the left mouse button held down, and the fourth requires you to click the left mouse button once, let go, move your mouse, and then click again to set the window/level. More complex features of the PACS products are even less similar than these basic tools.

These differences are significant and impact user productivity and satisfaction with the product. A small difference in usability is amplified by the repetitive nature of PACS workflow and can become significant when observed over time or aggregated

among many users. User satisfaction and productivity are very valuable and potential customers use these features to make purchasing decisions.

Architecture

While end users are concerned with usability, technical staff should evaluate products based on architecture. The architecture of current PACS offerings varies widely and the differences can be significant to an organization—how heavy the client is and how will it scale, how well will it integrate with current information systems, will it require staff with new expertise or can current technical staff support it, can the system be deployed as an enterprise PACS system, will it support remote workflow, etc.

Architecture differences frequently impacts users with poor performance or limited access. One system I worked with did not have a robust enough back end/archive system to handle our institution's volume of archive retrieval requests. This led to difficulty getting comparisons, a frequently critical part of providing accurate interpretations. Waiting for comparisons was frustrating, inefficient, and sometimes resulted in interpretations without comparisons—putting the radiologist and the patient at risk. The system is currently being replaced with a different vendor's product.

Interoperability

PACS systems need to communicate with other hospital and radiology department information systems and image acquisition systems. While the DICOM standard eases this communication challenge, vendor implementation of DICOM is not standardized and can complicate or completely hinder compatibility with other key department systems. Receiving data is an essential feature, but sending data to other systems is where current PACS systems vary most widely.

Sending data to other systems is becoming increasingly important especially for integration with voice recognition systems and for business intelligence systems. Business intelligence tools such as dashboards offer ways for practices to improve performance, quality, and safety[8]. However, the benefits of such a system can be held back by the PACS system. I am aware of a current dashboard project where getting information out of the PACS system is a major technical hurdle. As radiology departments and practices recognize the value of business analytics, they will select PACS products that will be compatible and reject those that are not.

Growth

The introduction of 16, 64, and higher slice CT scanners has dramatically increased the amount of data that CT scanners generate. 3D MR sequences such as SPACE and XETA also offer large data sets. This rapid pace of technological innovation has challenged many PACS systems in their ability to archive and display this massive amount of information. The large data sets offer an opportunity for radiologists for more advanced image analysis and for PACS vendors to implement the tools to perform it. These tools such as ad hoc multiplanar and curved plane reformats, automatic segmentation analysis, quantitative analysis, organ volume measurements, 3D representations, and computer-aided detection are far from maturity and end-user convenience.

A robust architecture and ability to interoperate hold great potential for transforming PACS systems into a larger platform—one that can encompass optical images from other specialties such as gastrointestinal medicine, orthopedics, ophthalmology, and pathology; more robust communication between clinicians; quality and safety measurement; business intelligence integration; and decision support integration.

PACS today is still a platform of innovation with a multitude of differences amongst current offerings from the vendors. A PACS system needs to continue to mature and adapt as our industry creates new multimodal imaging techniques and ever-increasing data sets. The significant variation in usability, architecture, and interoperability in the PACS market offers a myriad of features on which vendors compete. We have not reached the day when a CFO can or should be selected a PACS vendor without any input from the users.

THE PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IS A COMMODITY: JAMES CHEN, MD

Rebuttal

The word “commodity” has several definitions, some of which recognize that commodities can

have differences other than price[9]. Even the classic example of oil as a commodity misses that there are differences in features even in that commodity. Oil comes in different grades[10] (features), but at the end of the day, it provides its expected functions. PACS differ in feature implementations and some features, but like oil, at the end of the day, all PACS accomplish the same task, storing, retrieving, and displaying images for diagnostic interpretation. These differences in feature make PACS no less a commodity than oil.

Vendors must now find new ways to differentiate themselves. They must improve and leverage the value of their service organizations as their core differentiator. This benefits customers with more flexible and more responsive vendor service. The potential downstream effects on PACS customer business operations and profitability will be a competitive focus.

Growing imaging volume in both images per study and studies per patient will further the commoditization of PACS. This will more likely be a point of comparison for advanced visualization tools than PACS. Large data volumes require different paradigms of visualization to maintain efficiency[11]. These methods of visualization are not typically present in PACS, but are in the domain of the specialized advanced visualization vendors, well outside the core strength of the PACS vendors. Because of this, PACS will become a platform for launching the thin-clients of the specialized advanced visualization vendors, providing the radiologist with the ability to select the best-of-breed advanced visualization application at the time of interpretation, instead of being limited to the tools that PACS vendors will create.

I believe that PACS vendors will not be able to compete effectively with advanced visualization vendors in tools such as automated vessel segmentation and centerline extraction, CT and MR perfusion and MR spectroscopy, cardiac wall-motion, cardiac valve function, breast MR enhancement curves, multi-energy CT processing, and surface-shaded volume rendering. Though surface-shaded volume renderings may be considered fairly basic among the advanced imaging functions, the quality of these renderings can vary significantly even among the sub-specialized vendors[12]. The difficulty in competing effectively outside of a corporation's core competencies in advanced graphics and visualization is clearly evident in Intel Corporation's inability to compete in the discrete graphics chip market despite its vast financial and engineering resources[13]. Can PACS vendors truly compete outside their core competencies with the sub-specialized vendors, when even a corporation like Intel cannot?

At the end of the day, PACS and their vendors are now commodities. Vendors must improve and leverage their service organizations. Additionally, the increasing stability of PACS platforms will provide further opportunity for third-party vendors to innovate, much as the Apple's iPhone and Google's Android or Microsoft's Windows or Apple's Mac OS have provided platforms for third-party developers to create innovative solutions that increase the value of the underlying platforms. With the commoditization of PACS and their vendors, customers only stand to win.

THE PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS) IS NOT A COMMODITY: JOHN BRADSHAW, MD

Rebuttal

I would like to concur with my counterpart on one point. I agree that PACS vendors cannot compete with advanced visualization vendors covering the myriad of subspecialities in radiology. A PACS should act as a platform to support these other applications. A recent example of this strategy is Apple's iPhone app store. The app store combined an application programming interface (API) and business model that transformed a device into a market-dominating platform. While several PACS vendors recognize this direction, the PACS industry has simply not yet matured to this level where PACS vendors have developed open public APIs combined with the right business model to induce researcher developers to build applications on their platform.

The lack of modularity and inconsistent standard implementation throws up another barrier to commoditization. PACS vendors implement standards with enough variation, additions, and omissions to rob users of many of the benefits of standardization. Just consider the non-trivial technical, operational, and financial challenges of migrating data between PACS vendors. One of the signs that your product is a commodity is if it easily replaceable by a competing vendor's product[14]. This is certainly not the case in today's PACS market. It is the downside

of not being a commodity, but it is further proof that the PACS market has not been commoditized.

Perhaps the strongest argument against PACS being a commodity is that users want better products, not just cheaper products. In my experience with several PACS products from major vendors, most, if not all, users want more from the product. It is the nature of products in a competitive market to improve, implementing competitors' features. As the market matures, the differentiating features and point of competition evolve.

Eventually, the last point of competition is price. Looking back, the PACS market has indeed matured and competing features have changed, but they have not reached the point where competition is on price alone. In fact, considering the potential for innovation in the PACS market, we may have more future competition than we have had in the past. The radiologist will always need a PACS as their primary tool. As a result, all roads of innovation in radiology lead through the PACS.

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