PowerHealth Solutions Pty Ltd, Australia

Nominated by IDIOM Limited, New Zealand

1. EXECUTIVE SUMMARY / ABSTRACT

PowerHealth Solutions (Australia) [PHS] provides its "PowerPerformance Manager" and "PowerBilling and Revenue Collection" [PBRC] applications to healthcare organizations worldwide as 'Commercial Off the Shelf' [COTS] applications.

PHS started a rules initiative in 2004 that is the subject of this submission, with the objective of making costing/revenue and billing rules a plug-n-play feature within their applications. The separation of rules from the underlying applications was required to allow PHS to support bespoke customer rules within their otherwise standard applications.

In 2005 the Hong Kong Hospital Authority [HKHA] (42 hospitals, 121 clinics) tendered for a new enterprise wide billing application.

The current PBRC application was built in response to the HKHA tender and extended the scale and complexity of the rules then under management by PHS. When complete, PBRC provided a new rules-driven billing capability on the global market for enterprise health billing solutions, which was at the time dominated by heavily siloed, departmental scale solutions.

Since adoption of the rules initiative as described by this submission, PHS has expanded its footprint in its Australasian home market and expanded into overseas markets to include customers in the UK/Europe, the Middle East, South East Asia, and North America.

This submission uses the development of PBRC for the HKHA as a reference project for the initiative, to highlight the benefits of using rules as a formal architectural component within COTS applications.

2. OVERVIEW

PowerHealth Solutions (Australia) [PHS] provides its "PowerPerformance Manager" [PPM] and "PowerBilling and Revenue Collection" [PBRC] applications as 'Commercial Off the Shelf' [COTS] applications to healthcare organizations worldwide, with customers in ten countries to date.

The subject of this submission is the PHS rules initiative, which separated and promoted the use of rules within their COTS applications, supported by additional specific discussion around a single reference project that demonstrates key elements of the initiative.

The initiative is a key pillar of PHS's go-to-market strategy – it offers PHS's customers autonomy in the management of their business rules while also claiming the benefits of a COTS application. To achieve this, the COTS application is fundamentally refactored to include an interface to the rules engine, but no rules. The rules are then supplied on demand independently of the application itself.

The primary focus of the PHS rules is to convert raw patient encounter data into cost/revenue and billing data for the PPM and PBRC applications.

While the explicit focus of each of these applications is slightly different, the rules approach is consistent across the two applications. The separation of rules from the underlying applications allows PHS to provide bespoke costing/revenue and billing calculations from the otherwise standard applications.

Rules autonomy for the customer is flexible, with technology included within the rules toolset that provides an option for the customer to use PHS's rules, or to use the customer's own rules, either alone or in combination at any level of complexity. Both sets of rules, that is, PHS supplied rules and the customer's own rules, can by updated independently, so that rule sharing is complete and ongoing.

Using this technology, PHS can provide baseline, pre-configured rules that can be modified or added to by the customer (generally a hospital), who owns and manages the rules ongoing. Autonomous sets of rules can also be delegated to specialist departments throughout the enterprise, which are then dynamically re-acquired by the application and executed via the interface within the PHS defined rules topology, to achieve enterprise wide coordination of discrete sets of rules within a single enterprise wide process.

This approach required initial development and understanding of a rules topology, which was a critical outcome of the Project

The customer benefits and cost advantages of plug-n-play rules have helped PHS to become one of the world's largest suppliers of health costing/revenue and billing software, with expansion in its scope of operations since the rules initiative to the UK/Europe, the Middle East, South East Asia, and North America.

The reference Project for this submission is the Hong Kong Hospital Authority's [HKHA] enterprise scale billing system encompassing 42 hospitals and 121 clinics, and 64,000 staff. This project exemplifies the advantages of the approach. Since implementation of the new billing system, the HKHA have claimed improvements in business agility, managing enterprise-wide variations in business practice, and managing complexity and performance, while processing 1,650,000 invoice items in real-time to generate 4000 invoices per day at the point of care.

3. BUSINESS CONTEXT

PHS was established in 1995 with an innovative mission to build horizontal customer-centric applications rather than the vertical service or departmental centric applications that were then typical of the health market. The difference is significant – one billing platform instead of many; one bill instead of many; and enterprise wide access to unified costing/revenue and billing data, rather than discrete siloed viewpoints on an application by application basis.

In 2004, with customers in Australia and New Zealand, PHS recognized the advantages of using a rules approach: to manage the wide variety of cost input systems; to build a neutral middle-tier cost and revenue concept model; and ultimately to output unified costs, revenues, and invoices to service the wide variety of destination viewpoints required.

In 2005, the Hong Kong Hospital Authority issued a tender for a new billing system. The HKHA vision matched closely with PHS's vision for enterprise wide billing. At the time, PHS was the only vendor able to represent this concept and was uncontested within HKHA's prime vendor shortlist.

The proposed new PBRC rules-centric billing application was selected by HKHA. This required PHS to scale its rules approach to a new level, to span 42 hospitals and 121 clinics within a single billing system for consolidated enterprise wide, real-time billing.

The requirements sought by the HKHA at this time included the following:

- ***Business agility***

  The "hardcoded" business logic of the incumbent in-house developed system proved extremely difficult to change in response to new business requirements. As HKHA business practice is driven by external demand and government policy, it is imperative that new policies and policy changes can be actioned quickly.

- ***Enterprise-wide***

  The old system was hospital and episode-based and deployed as separate standalone systems at each hospital/clinic. Where a patient presented at more than one hospital, or was transferred between hospitals, they were recorded under different ID's with no data sharing between locations. As HKHA wanted to move to an enterprise wide patient based system, the only practical option was to replace the old system.

- ***Variations in business practice***

  Although the same core software was deployed across the organization, each instance operated independently and according to individual facilities' preferred billing processes. Invoices were branded with hospital identities and not the HKHA organization brand. Each system maintained separate patient records, and service codes were also interpreted inconsistently.

- ***Complexity***

  HKHA billing policy requires complex decision making based on many factors. The in-house development was struggling to meet these requirements. It was therefore a top priority that the replacement software could handle both the

complexity and need for regular change without constant enhancements to the underlying program code.

- ***Performance***

  To operate effectively the HKHA billing model required a patient facing system that provides fast turnaround in order to issue invoices and collect payment at time of service. Time taken by the billing system to generate an invoice while the patient is waiting is therefore vitally important, particularly during peak periods.

From a rules perspective, both PBRC and PPM have the need to transform large numbers of raw cost events for each patient encounter into intermediate forms before generation of invoice line items or service delivery costs/revenues respectively.

An encounter refers to a period of treatment more or less from admission to discharge. For the sake of clarity, the encounter refers to the period rather than the treatment, so that one encounter may include many treatments. This subtle distinction is important because the various treatments may require multiple sets of discrete funding rules from a variety of funding parties that may overlap. Partially for this reason, the rules need to transform the inbound cost factors into more or less neutral concepts before re-collating them by funder/funding agreement. At this point, cost sharing and allocation rules may add significant complexity.

For instance, consider a patient having a private knee operation who has heart failure during anesthesia – which funding agreement pays what in these circumstances? Until discharged, this constitutes one encounter, and for inpatients, this can be an extended period (usually days, but extending to years in some cases).

The input costs span many medical and support disciplines, while the revenue is likely to be derived from multiple funding agreements, both public and private.

In each case raw medical and administrative 'factors' that describe the consumption of the health provider's resources are acquired by electronically receiving messages from a wide variety of clinical and administrative systems. The totality of these messages includes all data required to calculate correct costs and charges according to defined rules, and may include service codes, ward transfer details to calculate time spent in wards and other locations, and/or data coded using industry coding systems such as DRG & ICD.

These raw message items need to be transformed into a neutral, schema defined format. Some of these costs are attributed directly (e.g. a service is provided) or they may be apportioned indirectly (e.g. overhead for a particular ward stay based on presence in the ward), often on an hour-by-hour basis.

These items then need to be transformed into cost, revenue, and/or billing values in accordance with the contract rules in multiple funding agreements. Meta rules regarding shared funding, capped funding, and other cross-contract aggregation or apportioning also need to be applied, which can add significant complexity.

These rules come from different sources, including PHS themselves, the hospital organization, and the multitude of public and private funding agencies. Often, the funding contracts are the same or similar across hospital organizations, providing an additional opportunity for sharing of rules.

Coding each hospital's rules from scratch is expensive and time consuming. PHS therefore seeks to provide rule supersets that provide a more or less complete set of rules for adjustment and tailoring during the implementation process. By using a rules engine to achieve this, the application is relieved of responsibility for man-

aging these rules. In fact, the PHS applications are not aware of the rules they contain – they are only aware of the specific outputs that are generated at the conclusion of each rules cycle. This means that one COTS application image can manage the cost/revenue and/or billing rules respectively for any and all hospitals across multiple jurisdictions.

In summary, the rules engine must manage a complex set of transformations at scale, to ultimately apply a complex set of rules representing multiple parties while maximizing the reuse of rules on a global basis.

4. THE KEY INNOVATIONS

4.1 Business and Operational Impact

The PHS Initiative

Using a rules engine that accepts rules from multiple sources (both internal and external) and which executes them as a contiguous set has allowed PHS to offer an agile and cost-effective solution to its customers worldwide. By normalizing and reusing rules at many levels, including global rules, jurisdictional rules, rules per funding contract, and rules for each and every cost center in the hospital, PHS has been able to reduce the investment required to convert cost items into cost/revenue and/or invoice line items in accordance with funding contracts and the hospitals own cost accounting procedures.

This has led to increased sales, and ultimately, global expansion.

The HKHA Project

The HKHA project exemplifies the benefits of the initiative described above. In the first year of operation, the metrics included more than 20million encounters, with nearly two million inbound cost messages per day resulting in several thousand invoices being presented in real-time at the point of discharge per day.

The validation and transformation of these cost elements required unique algorithms for each specialist department. There are 26 distinct decision models operating in concert to achieve unified, enterprise wide billing.

The result is fine-grained variation in rules while maximizing reuse on a large scale.

In achieving this business objective and throughput, substantial complexity was addressed. In business terms some examples include:

- ***Radiology weighting rules***

  Using PBRC's business rules engine, HKHA can group radiology charges by order number and modality and apply a discount where the patient only pays for the 4 most expensive items on a sliding scale. The business rules use the minimum allowed price in the official gazette to control the level of discount.

- ***Invoice bundling***

  HKHA has complex cycle requirements for determining when to create invoices for different situations and how to group the charges on the invoices. These are configured into workflows which automatically generate invoices at the appropriate times.

- ***Teaching hospitals***

Complexities due to local variations in charging models were easily configured into PBRC's enterprise billing logic. For example, PBRC calculates charges and splits revenue differently for teaching hospitals where the university shares the cost of delivering services and receives a revenue share as payment for university doctors working at the hospital.

- ***NEP Obstetric Services***

  HKHA requested a non-standard NEP Obstetrics module to manage growing demand for obstetric services from mainland China by non-eligible persons (NEP). PHS delivered the functionality to handle registration, printing, and issuing of certificates, as well as booking antenatal appointments, tracking attendance, and receipting payments. The flexibility of PBRC's configurable logic allows HKHA to maintain this module in compliance with future policy changes.

Increased business agility was demonstrated by a Radiology charging policy change. Shortly after the go-live, HKHA needed to change the radiology bundling logic, which had the most complicated business rules. PHS consultants worked with HKHA to rework the business rules and deployed this mid production. The transition went smoothly and the new charges took effect without impacting the previous charges or affecting the go-live schedules. This was an excellent demonstration of the system's business agility.

4.2 Innovation

In the case of health cost/revenue and billing management, there are a series of distinct transformations that are required to deliver value to the organization by managing the inherently complex many-to-many relationship between input raw cost factors and output revenue line items.

There are three major transformations required to resolve these many-to-many relationships:

- Transform unqualified raw data as supplied by external systems, into validated and standardized data that appropriately describes the required input costs;
- Transform validated, standardized input costs into the neutral idiom of the rules metaphor;
- Transform the costs now described by the idiom into the value-added outcomes required by each user of the application – new values, new reports, new workflows.

These three transformational phases form a standard design pattern for solutions that need to manage complex many-to-many rules matrices between inputs and outputs.

Firstly, raw data is input to the rules – raw data describes the external reality. In most cases, the raw data is more or less equally available to all organizations because it is inherent to the domain – it is commodity-like, which allows the COTS application interfaces to be standardized. The rules that are involved in on-boarding this data into the rules domain are tactical in nature, essentially designed to ensure that the quality and quantity of data is sufficient to be able to achieve the ultimate purpose of the rules (e.g. billing values). These are the validation and acquisition rules.

Once the raw data has been acquired and validated, it starts its transformation journey towards the idiom of the organization that is seeking to harvest value from the data. It is normal for this intermediate step to generate a complete new state that is described in quite different terms to that of the raw data, but which is nonetheless internally consistent with it.

For instance, ward arrival and departure times for both patients and staff in the raw data might be transformed into an apportioned cost per hour per patient in the intermediate format, before the final transformation into actual billing items as defined by contracts, which might then include per diem payments, co-pays, lump sum payments etc. Note the distinct transformations – preparation and input of raw data into the idiom that is aligned with the purpose, then into the outputs, namely new state values, reports and workflows.

The three basic steps described above can be further complicated by internal domain and organizational variations.

It usually requires a range of subject matter expertise to validate and transform each of the domain specific elements into the billing or costing idiom.

Consequently, there is a rules topology that has multiple dimensions, starting with the basic three steps – validation, transformation into the idiom, derivation of outcomes.

This is then compounded by areas of domain expertise on the input side (see the 26 models of the HKHA billing repository below), and by the management disciplines that require the outcomes (billing, accounting, audit/compliance, operations/workflow, personnel management, etc.).

The above is a screenshot taken directly from the rules development tool.

The rules topology might involve dozens of substantial algorithms (which we call decision models) that all need to be orchestrated in a single process to onboard the reality as described by the raw data, and to ultimately produce the variety of outcomes that are desired by the various internal and external consumers.

In order to manage the navigation of various use cases through this topology, we have developed the concept of a control model. A control model is another algorithm whose purpose is to orchestrate the flow of each transactional use case (in this case, a patient encounter) through the topology.

The control model also allows us to add another dimension to the rules topology – that is time. Over time, we need to add and change the models that comprise the topology. If we run our use case from last year through the rules topography, it should obey the rules that applied last year. This requires an 'effective date' concept that is universal across commercial rules use cases. With a control model, we can orchestrate the application of complete decision models through time.

Providing each specialty with a unique decision model gives the business the ability to fine-tune hospital cost and revenue management without impacting other rules or the application itself. These changes can be made and deployed locally at any time. The conversion of unique cost structures into a standard idiom provides a value-added bridge, a 'safe-harbor' that allows the business to resolve the complex many-to-many relationship between input costs and revenue received, at the individual item level.

Dealing with the cost aggregation separately from the revenue item generation significantly reduces complexity – no one person or algorithm has to deal with the end to end complexity. In fact, the complexity 'emerges' from the integration of multiple simpler sets of rules, each of which is of manageable complexity by individual subject matter experts – dealing with the cost complexity alone and separate from the revenue complexity gives us complexity times two; trying to resolve the many-to-many relationship in a single algorithm gives us complexity squared.

The major innovation is to reduce the complexity of the whole by addressing it via many individually simpler models, and to then reassemble those models into an end to end solution on a just-in-time basis inside the rules engine, using a rules topology with a control decision model to orchestrate the multiple parts. The concept of a control model to orchestrate the topology is novel and reduces the complexity as it is seen by individual rules authors – no individual or group needs to see or address the full scope of complexity.

4.3 Impact and Implementation

The approach taken for the HKHA Project, and repeated throughout the PHS Initiative, is to allow the customer to use any preferred strategy for the internal management of their rules. An initial roadmap for the required rules topology is provided by PHS. It is the customer's responsibility to provide the rules within the constraints of the topology, regardless of whether they use default rules supplied by PHS, their own rules, or a combination thereof.

This approach allowed the Project to quickly develop the original topology, which includes the 26 decision models in the preceding screenshot that cross 26 areas of expertise and are supported by 155 reference tables to provide a complete, correct, and consistent enterprise wide set of rules.

The 26 decision models shown above generate ~300,000 lines of Java code when deployed, which demonstrates the scale of logic involved. This volume of code makes the rules a substantial component of the overall solution.

The complete set of HKHA rules was developed in approx. ten weeks of rules development effort, including 7 weeks consultancy support from the rules vendor, within the nearly two-year development and implementation effort for the entire PBRC (circa 2009-2011).

The rules have been fully supported by the HKHA without vendor support since go-live 7 years ago.

This Project demonstrated improved development and operational efficiency while addressing enterprise wide complexity for a substantial organization.

5. HURDLES OVERCOME

Some specific hurdles itemized by the PBRC Project team include:

- Managing User and Cluster Executive expectations – where there was a very high level of expectation that the new PBRC would deliver complete flexibility for the foreseeable future, satisfy all of the functional deficiencies inherent in the old home-grown application, and provide significant additional functionality to cater for requirements not previously covered by a software solution. Requests for functional enhancements were further driven by the knowledge that the software was under development when the implementation started, and the cultural change from implementing commercial off the shelf software (COTS) rather than an in-house developed application.
- Occasional significant variations in business practice and interpretation of Government policy and HKHA billing rules between management clusters, prompting the need to obtain consensus between cluster management and users to define a common set of rules that were acceptable across all HKHA entities.
- Highly complex integration requirements arising from the number of feeder systems that needed to automatically provide essential data to the new PBRC to enable automation of the billing process, compounded by the need to retrofit a message-based integration architecture to existing HKHA applications – 18 separate systems required 58 distinct interfaces. In addition, a significant number of data gaps in the essential data required from feeder systems needed to be closed by the integration solution, along with data mapping to resolve variations in service codes used by the various clusters.
- To eliminate the need to have a very lengthy transition from old to new systems with both running in parallel for a significant period of time, very large amounts of data needed to be migrated from the legacy to the new PBRC. The migration process was in itself a complex project as it was not a simple one to one transfer of data but involved a considerable amount of data enrichment on the way through.
- The Pilot site status of the implementation arising from selection of a new generation software product that had not previously been implemented as an Enterprise-wide solution for such a large and complex organization as HKHA. The testing strategy therefore needed to be very detailed and extremely thorough to ensure all potential business scenarios were covered as well as meeting demanding performance goals.
- Ongoing scope change caused by addition of new functionality to solve previously out of scope business problems, and enhancement of current product

functionality i.e. over the life of the HKHA implementation project, PBRC moved several years forward in a normal COTS software development lifecycle.

4.1 Management

Belief is a key issue when developing at this scale because the elapsed development time becomes a critical factor in its own right.

The rules technology has its own on-board execution and testing environment, so that rules can be developed and tested in parallel with the development of the underlying applications.

This provides 'quick wins' by making key business outcomes visible early in the process, helping to sustain belief and giving breathing room to the more traditional SDLC elements in the Project.

4.2 Business

A critical objective of the Project was to enable customer ownership and management of the rules. This was achieved by working closely with the subject matter experts [SME], who were customer staff, to empower them in managing their own rules. Previously, these rules were codified in system code in multiple systems and were not visible or directly available to the SMEs.

In this Project, the transfer of active rule management was fully supported by the rules tool vendor, so that during the development of each and every set of rules there was an active process to handover rules understanding and ownership. When each set of rules was finished, the new SME custodians assumed ownership going forward. As a result, handover was more or less simultaneous with go-live.

4.3 Organization Adoption

Testing was a major issue for an enterprise system of this scale with nearly 1000 active users at a dozen different locations.

HKHA developed some 14,000 test cases in preparation for meticulous and rigorous user acceptance testing. These test cases were developed by the HKHA implementation team in consultation with users. Over the course of the user acceptance testing process the HKHA project team invited selected users to the head office for week-long sessions, to test the scripted scenarios and to undertake freehand testing.

During the implementation process, the HKHA implementation team logged some 2,000 support logs covering functional as well as performance issues. The greatest majority of issues were resolved and closed prior to the first Go-live, with a few deferred for incorporation as subsequent enhancements to the core software.

Some of the logged issues related to requirements that had never been delivered before by a COTS billing package and resulted in addition of new functionality into the core product in order to deliver a robust and fit for purpose solution.

For example, Hong Kong's social services can issue waiver certificates which apply discounts to charges in a logical but complex fashion. Where a patient has multiple certificates with overlapping periods, there is a set priority which is used to determine which certificate gets applied to the charges. But there are other receipting systems upstream of PBRC, and a patient may have presented to them a different waiver certificate. It is important that PBRC retains the integrity of the receipting

which occurs upstream. New functionality was therefore added to enable exceptions to the waiver priority, with specific charges being reserved so as to allow waiving by one specific waiver certificate and no other. By necessity this has been designed to work even if the certificate and the charge have not yet been created in PBRC. There were many such significant enhancements to the core system.

Go-Live

The first phase was rolled out to 318 users in 7 participating hospitals.

Radiology format change

2 months prior to the go-live, there was a change in the Radiology message format. This had a major impact on the automated interface linking the Radiology system to PBRC. The interface was modified and deployed within a month, without affecting the go-live deadline.

Rehearsals

The first go-live underwent 3 cutover rehearsals, where selected participating users used the new system for 1 week, concentrating on one thing at a time:

- The 1st rehearsal focused on product readiness
- The 2nd focused on staff and hospital readiness
- The 3rd focused on readiness for handling the transaction volumes.

Go-Live Sequence

On day one of the Go-live process the old system for the relevant hospitals was switched off, and the new system switched on.

Billing operations continued by using manual processing for 1 week, while data from the legacy system for each separate go-live site was migrated into the new enterprise system.

At the start of the next week, all billing and receipting activities commenced using the new system.

Performance

The go-live went smoothly with most attention being focused on data volumes and performance tuning. Application issues that showed up were minor edge cases and workarounds were used while the issues were being resolved.

Radiology charging policy change

Shortly after this go-live, HKHA needed to change the radiology bundling logic, which had the most complicated business rules. PHS consultants worked with HKHA to rework the business rules and deployed this mid production. The transition went smoothly and the new charges took effect without impacting the previous charges or affecting the go-live schedules. This was an excellent demonstration of system's business agility.

Remaining Users

All other users were converted in two tranches on schedule and without incident.

6. BENEFITS

6.1 Cost Savings / Time Reductions

PBRC design philosophy separates business logic and high-level workflow processing logic from the core software processing functions, to allow for customization by configuration rather than changing core software program code. This met HKHA's top priority of business agility.

Business logic

PBRC uses a rules engine which has a graphical interface for modelling business rules. HKHA staff can modify these rules in response to changes in business policies and government regulations, and deploy these changes swiftly. For example:

- "Income splitting" rules to calculate the division of revenue between HKHA and private practitioners, based on individual agreements.
- "Radiology bundling" rules to generate individual charges for all services, calculate several possible packaged permutations, and select the cheapest package and individual charges for the patient.

Processing logic

PBRC uses a workflow engine for controlling billing processing. HKHA staff can configure the workflows to customize the billing processes. For example:

- Eligibility checking — perform webservice callouts to the public sector (for employee rates) and the immigration department (for citizen rates) to verify financial class.
- Administration fees – where an additional charge (late payment fee) is automatically created once a patient's invoice becomes overdue.

Consolidated invoices: PBRC servers are located at HKHA data centers, serving users in hospitals and clinics throughout Hong Kong, Kowloon and New Territories. PBRC bills for services from all locations in a consolidated patient invoice, thus simplifying invoicing and payment for both patients and HKHA, resulting in a reduced number of transactions and improved efficiency.

Reduced labor costs

Increased automation reduces the amount of manual input and labor cost, as fewer clerks are needed to perform manual procedures.

Reduced operational costs

By consolidating previously separate systems into one new enterprise billing system, HKHA experienced cost savings e.g. computer servers, office space.

Reduced maintenance & support effort

With a centralized system, HKHA IT can more easily resource the maintenance and support. For example, upgrades are now performed once instead of multiple times as is required by a distributed architecture. System administrators find it much easier to monitor and tune one system instead of many. Additionally, the client PCs require minimal maintenance and support with PBRC launching from a web browser, where relevant software upgrades are performed automatically.

6.2 Increased Revenues

Invoicing and receipting at Point-of-Service

In some circumstances HKHA policy requires payment prior to treatment with generation of invoices on patient arrival at the point-of-service. This time-sensitivity places significant performance demands on HKHA billing processing speed, especially at peak times. PBRC's scalable architecture allows real time addition of software agents and hardware servers to meet fluctuations in processing demand.

Monthly statements: Patients with outstanding accounts are sent itemized monthly statements, with amounts paid & owed and an optional reminder of when payment is due. This makes it easier for patients to settle their accounts and results in improved HKHA cash flow and reduced outstanding debts.

6.3 Quality Improvements

- ***Reliability***

With their complicated business logic configured into the system, HKHA can be confident that charges are being applied correctly, consistently and reliably. Discrepancies due to human error are eliminated by this automation.

- ***Centralized revenue collection***

With the new enterprise-wide system, invoices can now be paid at any HKHA facility regardless of where treatment is received.

- ***Standardized procedures***

The patient-based system has centralized billing services and introduced consistency to HKHA billing as all hospitals are now using the same system and procedures.

- ***Enterprise reporting***

With a single enterprise-wide repository, prompt and accurate reporting across hospitals, patients, and services is now possible.

- ***Organizational management***

PBRC supports central administration by HKHA head office and distributed management by the HKHA clusters.

- ***Corporate branding***

All PBRC documents such as invoices and statements are custom formatted, and HKHA IT staff can easily deploy changes by simply updating the document templates.

- ***Efficient revenue collection across all locations***

Previously payments could only be collected by hospitals and clinics for services provided at that location. PBRC now detects outstanding amounts for all locations and HKHA can therefore request payment for outstanding amounts when a patient presents for treatment at any location.

7. BEST PRACTICES, LEARNING POINTS AND PITFALLS

7.1 Best Practices and Learning Points

- ✓ *Developing a rules topography to guide rules development is an important precursor step to take in any rules development and is essential for effective normalization of rules.*
- ✓ *Rules should be fully normalized – this means the fewest number of rules to implement the required algorithms, which by definition means that the algorithm is in its simplest form.*
- ✓ *Normalized rules allow greater agility (less to change), fewer errors, more reuse, and less development effort.*
- ✓ *When rules are normalized, it follows that patterns for reuse of rules must be achieved at many levels, with special emphasis on the decision model itself. This is the driver for a rules topology.*

- ✓ *Identify and develop the core rules first. These are the rules that define the **purpose of the system**. Then follow through with development of transformation rules, validation rules, and finally workflow and reporting rules. That is, build from the inside out, starting with the core, and working back to the inputs (via transformations and validations), and then working forward to the outputs (new state values, reports, workflows).*
- ✓ *Use the best subject matter experts to develop the reusable rules in order to codify and then leverage their expertise.*

7.2 Pitfalls

- × *In general, avoid the antithesis of the above.*
- × *Don't build monolithic rules structures that mix purpose and expertise.*
- × *Don't mix rules by type in the same algorithm (e.g. core calculation, transformation, validation, workflow, etc.).*

8. COMPETITIVE ADVANTAGES

PHS takes on what no other organisation seeks to do. For example, with PBRC PHS recognized that public hospital billing was fragmented and inefficient and no vendor actually specialised in patient billing. Existing systems were all linked to a clinical application, albeit large multinationals, but if you wanted a Pharmacy, Radiology or Pathology system, then you bought that system and each came with their own billing module. This implied separate staff, training, accounts receivables, etc, for each system. It also meant that at times, the decision on what clinical system to buy was greatly influenced by the appropriateness of the billing module that came with it.

What PHS has done is to say 'don't worry about the billing module that comes with any clinical application; PHS has developed a fit-for-purpose enterprise-wide billing application that integrates to all clinical systems and is dedicated to automating and simplifying the billing process across all customer clinical applications'.

What's more, billing rules were typically coded into the application but because a billing system is in essence an accounting package, while billing rules change all the time, it was disastrous to have a system that should remain consistent in its behaviour while the code was changing all the time. PHS realized very early on in the development of PBRC that an appropriate logic/rules engine would be ideal to code billing rules. This decision was made in 2004, fully 18 months before Gartner published an article extolling the benefits of adopting a rules engine as part of any software development project.

PHS has a four-step commercial strategy to encourage customers to stay committed to the substantial advantages described above:

- PHS doesn't license as a SaaS model. We license with an upfront license fee and implementation and then a 20% annual support fee. The sale is harder to get but this ensures that as new tech is introduced, which is cheaper and would likely undercut an existing SaaS model pricing, that new price will still be much higher than what our clients are paying at 20%.
- Maintain a very high Net Promoter Score (hovers between 65 and 75. Apple has a 70) by providing great support to all our clients
- Invest significantly in R&D to keep the product continually fresh and relevant.
- Following the initial 3-5year Term, offer our clients new modules (developed under R&D) free of charge with a 3year renewal.

Given clients are satisfied, have access to new functionality every 3 years free of charge and would have to pay more for an alternative solution, PHS is able to keep clients long term. Only one client has ever stopped using a PHS system in 16 years. That is how PHS sustains completive advantage.

9. TECHNOLOGY

The use of a rules product fosters a fundamental redesign of the traditional SDLC by fully separating the development and automation of business policy (deciding) from development of the system's activities that support it (doing). This is effective in spawning a 'Business Policy Development Life Cycle' that is managed independently of and alongside the traditional System Development Life Cycle.

The rules technology used offers a number of compelling features to support this:

Scale and Complexity: The rules development paradigm, and its supporting decision engine, was required to deal with substantial complexity across the entire scope of the enterprise. That is, the scope of rules, and their interrelationships, extended across all aspects of the enterprise. With 42 hospitals and 121 clinics supporting 20million patient encounters per year in our reference Project, the scale was substantial. In this case, the rules technology was able to address many distinct sub-domains (e.g. each specialist area) in a clear, consistent, and coordinated manner without introducing additional complexity.

Performance: Millions of items per day are being processed, with outcomes required in real-time at the point of discharge for the patient, and sometimes before. The rules technology generates compiled code that can run 'in-process', so that minimal processing overhead is incurred. Rules processing per output item is in the single millisecond range and means that the overall application is able to achieve the customer's desired performance benchmarks. The rules process is stateless and thread-safe, so as many instances of the rules can be used as required to achieve unlimited throughput while maintaining fast response times.

Ease of Use: The initial rules approach and rules development was performed by PHS with the assistance of the rules vendor. Seven weeks of assistance from the rules vendor delivered approx. 70% of the rules development, with the balance delivered by PHS and HKHA domain experts. Rules training for HKHA occurred as an intended byproduct of the rules development process, so that after a few days additional training, the rules were handed over to the customer as part of the go-live transition. This specific customer has managed the rules independently since (a period of seven years) without a single service call to the rules vendor.

Versatility: In addition to the 'business end' of business rules (calculations et al), the rules can be used for more traditional IT functions that also rely on standard, user defined logic including: validation and transformation (the heart of EVTL) at the entry point; and reporting and workflow (what do we need to do now) at the exit point. This demonstrates versatility in how the rules are able to be used.

Data Agility: A simple change to an XML schema is all that is required to introduce new facts into the scope of the rules by the application. Data can be added at will on an ongoing basis and are immediately available to subsequent rules processing.

Time Sensitive: All rules are effective dated at every level and are always executable as at any effective date – past, present, or future. This means that long lived use

cases can span changes in business policy and always be evaluated according to the applicable policy at the time, which is itself a policy issue to be controlled by rules (do you charge as at time of admission, time of discharge, re-price on annual boundaries, etc.).

Version Consistency: The technical format of the rules has been backwards compatible since the inception of the rules product (2001), so that version upgrades in the rules are never mandated by technology requirements. Of course, new product features can only be accessed with new versions, however the rules themselves will always execute without change in all future versions of the rules product.

On Board Execution: The rules tool has an on-board execution engine and extensive support for both on-board step-by-step and full regression/simulation testing. This allows an independent rules development cycle that can start early in the project to provide morale boosting optics and important requirements feedback for the more traditional SDLC developments, as well as significantly speeding up development and reducing testing overheads across the project. The complete independence of the rules development cycle provides many advantages, including multi-party rules development; rules production prior to, during, and after applications development; and smaller and more durable applications.

As a consequence, we achieve the following key Value Propositions:

- 100% alignment of systems-based decision making with business policy, because the business owners have hands-on custody and control of the policy definitions actually used by the system.
- Increased agility with reduced business risk through business modeling and empirical testing of policy definitions prior to automated generation and implementation.
- Significant reduction in the business cost of developing and implementing automated business policy.
- Further reduction in software development cost, time, & risk through reduced system complexity, fewer moving parts, & clear separation of concerns.

10. THE TECHNOLOGY AND SERVICE PROVIDERS

PowerHealth Solutions (Australia) powerhealthsolutions.com

PowerHealth Solutions is an international healthcare software company specializing in Costing & Revenue, Enterprise Billing and Safety & Quality software for hospitals and other healthcare organizations.

PowerHealth Solutions supplies the “PowerBilling and Revenue Collection™” and “PowerPerformance Manager™” applications.

IDIOM Limited (New Zealand) www.idiomsoftware.com

IDIOM Limited supplies the IDIOM Decision Manager™, which was used to construct all decision models referenced in this case study. IDIOM Decision Manager™ is a graphical modelling tool that is used by subject matter experts to build, test, and deploy very large and complex decision models for any domain.

Finis