

## Data Integration and Analysis for Performance Management in a Modern Police Force

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### Abstract

*This paper presents the development of an enterprise level Service Oriented Architecture design aimed at resolving the data access, integration and analysis issues of an existing multi-supplier and heterogeneous infrastructure commonly found throughout the UK Police Service. This paper describes new developments that deliver the data integration and new analytical needs of Performance Management and ensure access to timely, accurate and relevant data throughout the Force. A 'proof of concept' prototype has successfully been developed and implemented to demonstrate the feasibility of extending the life of legacy systems and using services to abstract data into a new Analytical Processor. The architectural model and resulting prototype have successfully demonstrated the feasibility of this development to deliver the data integration and analysis needs of Performance Management within a UK Police Force.*

### 1. Introduction

The aim of this paper is to present the development of a Services Oriented Architecture (SOA) that enables data integration and analysis to support the Performance Management process within a UK Police Force.

The background context is given, and then a description of three new areas of development that deliver the integration and analytical needs of Performance Management and ensure access to timely,

accurate and relevant data throughout the Force. These are:

- An Overarching Service Oriented Architectural Model.
- A Common XML Messaging Specification and Standard Web Service Design to extend the functionality of legacy systems towards new requirements.
- A new analytical processor to 'close the loop' on Performance Management.

A 'proof of concept' prototype has been deployed to test the functionality of the architectural initiative and its ability to provide a longer-term strategic technical direction that can guide and deliver the future system and data integration needs of the Force. In conclusion, the evaluation discusses the positive impact and future applicability of this data integration and analysis approach in support of Performance Management within a UK Police Force.

### 2. Background

#### 2.1. Context

The British Home Office, after the Soham murders and the London bombings, created a focus on Police intelligence gathering [1, 9]. The data of intelligence is the regular work of Police Constables (PCs) on the street. Directing PCs on the street is the work of databases kept in each Basic Command Unit (BCU) - courts, probationers, arrests, etc. minimally configured to do just one job each [8]. The Home Office produced an XML model of Police assets and reports and

thought it could help as a model of intelligence reporting [4].

Performance management became the way forward [2, 9 op. cit.; 14], but only if it could handle intelligence gathering from BCU systems and report to the Home Office via their XML model. The advent of new technology Service Computing suggests the way forward for its ability to integrate disparate systems via an Integration Manager without replacing the existing database infrastructure.

## 2.2. Police performance management

Three example business areas, core to the Force's Performance Management requirement, are directly linked to the management and outputs of:

- the process of crime recording and investigation,
- the detention of offenders under the custody process, and
- the integration of data for criminal intelligence purposes.

However, the absence of timely, relevant and accurate data that is easily captured and capable of supporting the Performance Management processes was identified as a major barrier to effectiveness [8 op. cit.]. Data is held in numerous, disparate electronic source systems of varying proprietary formats and requires manipulation, transformation and calculation before it can be used in any analytical performance context. Much data for Performance Management is collected, but its capability to support a management process is an area of concern and frustration [8, op. cit.]. This barrier is corroborated by the Police Standards Unit (PSU) as a common issue in most UK Police Forces [14 op. cit.].

## 2.3. New performance management initiatives in UK Policing

Several UK Police Forces have developed initiatives to address the data needs of Performance Management. These initiatives have been a central data warehouse and the use of extract, transform and load (ETL) routines. However, due to the tight coupling of data extraction based on complex proprietary standards, the current 'best so far' solutions have become increasingly difficult to maintain and even more complex to develop further [8 op. cit.].

Further, research into national policing has identified that there is no physical implementation model to develop the technology for support of and access to timely, accurate and meaningful performance data. The current national initiatives, including the

Information Systems Strategy for the Police Service (ISS4PS) and the IMPACT programme (for sharing information to prevent and detect crime), place reliance upon the National Management Information System (NMIS) [16, 17].

The strategic technical vision for the UK Police Service under the Information Systems Strategy for the Police Service focuses on the future development of an enterprise wide SOA implemented through the use of Web services and standard XML messaging structures [17, op. cit.]. However, the strategy only provides a potential future vision for the next decade and not a physical implementation plan that can be applied to tackle the issues and barriers identified.

ISS4PS acknowledges that the ability of forces to move directly to a single national standard and architecture may require a phased or staged approach because of the multitude of police systems currently in use. The national strategy considers the use of Enterprise Application Integration (EAI) as a step towards achieving the final integration solution. The use of a staged approach can be considered to highlight how all Police Forces are subject to reduction in budget and continual financial savings, resulting in increasing difficulty to replace existing source systems and 'start afresh' with a pure SOA solution.

## 2.4. New Service Oriented Architectures

SOA and the use of XML Web services is now considered as one of the most agile and capable solutions to achieve successful data integration across multiple proprietary systems [6]. To avoid the tight coupling of proprietary standards or logic resulting from the functionality of third-party supplied data systems, the top down design approach commonly associated with SOA has been applied to the design and development of this architecture [10,13].

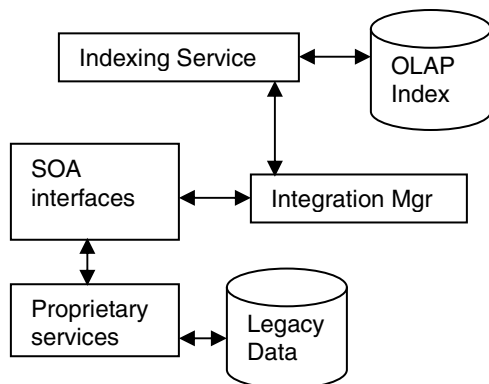
## 2.5. XML Messaging Specifications

The UK Police Service has addressed standardised data structures with a corporate data model and corresponding XML schema specification [5]. The CorXML specification describes core business activities and associated strategic business objects such as people, places, vehicles and property. However, the practical use of CorDM with existing data systems is considered difficult by many forces due to a lack of guidance and semantic inconsistency when attempting to map a proprietary system schema against this national specification. This difficulty is further compounded by the national police data sharing programme (IMPACT), driven by the Bichard enquiry,

and the differences between CorXML and IMPACT XML specifications [1, 8, 16 op. cita.].

### 3. An SOA service architecture for a UK Police force

The overarching architecture presented in this paper (see Figure 1) takes the principles of a SOA and wraps existing source systems with loosely coupled Web Services based on a common messaging format and common functionality to abstract the underlying logic as standardised interfaces that expose non-proprietary message endpoints. The architecture shows standard business services (web service interfaces as wrappers to proprietary systems) and a new analytical indexing service specific to Performance Management to control and manage service interaction through the concept of an Integration Manager. This architecture further reduces the complexity of a heterogeneous multi-supplier environment by removing the need to interact with raw data based on numerous physical systems, proprietary logic and varying technologies.



**Figure 1. Overarching architectural concepts**

This approach retains the ability to interact with the specific functionality and logic of a source system to ensure data is accessed in the same context in which it was originally collected and stored before any data mapping is applied. This feature of the architecture supports a Police process requirement by allowing multiple common business services to access data while maintaining evidential integrity.

A new Analytical Indexing Service for Performance Management and inclusive business services, implemented as an On-Line Analytical Processing (OLAP) system, is enabled by the architecture. This service will maintain an OLAP data index and deliver coarse functionality that underpins performance in order to provide a single point of access to data and

encapsulate further routing to other services as additional detailed data is needed [11].

### 4. An XML Messaging Specification and Standard Web Service Design

The ability for service interaction and communication based on defined message endpoints is an SOA building block. A common XML specification that can be used across the entire architecture is required in order to facilitate this message-based communication. This standard XML structure will abstract multiple source systems and their non-standard data structures, and enable cross-platform interoperability with support for loose coupling by representing data structured around business processes and not physical data storage [15].

Six generic data dimensions have been identified to establish and define the granularity of both the business activity services and also the analytical indexing service to achieve the Force's Performance Management needs. These are: activity status, date ranges, type codes, geographic locations, teams and individuals.

In addition, all business activities are tracked and linked by process-specific reference protocols that are often different to the access routes expected by the underlying source systems. To address Performance Management requirements, data are further layered based on counting rules derived to overcome the variety of formats for transactional data and recording practices in many of the Force's source systems [8 op. cit.].

To reflect the practical needs of UK Police Forces and their current systems, and taking into account future national and strategic constraints and implications, an XML specification has been defined at a Force level [3]. This XML specification is a fundamental part of the architecture presented in this paper. The concepts of this XML specification have taken the core elements of CorDM and CorXML for the key business activities and supporting strategic business objects [4; 5 op. cit.].

This XML specification for the Force (CP-XML) is central in the overall architecture and is focused on core business activities and not individual source system data structures. This approach enables definition of business objects with common functional granularity and implementation of loosely coupled services to use those objects in a service-oriented environment. The CP-XML specification has been derived in order to develop a practical solution that can be used consistently throughout the CorDM and CorXML architecture [3, 5, 16 op. cita.].

The resulting CP-XML specification has taken an innovative view of police business objects within the Force; CP-XML will not only support the needs of one Force's Performance Management but also addresses national policing demands by simplifying any further data mapping. Further, this approach overcomes issues of semantic dissonance when integrating supposed common objects from different systems where the semantic meaning in each system is different [11 op. cit.].

Web services which constitute the software architecture have been developed to implement business processes with coarse-grained functionality and communication using a standard messaging specification. The messaging granularity and service interaction of the architecture is enabled by the Force-specific CP-XML specification to provide standard communication. Developing web services around defined business activities further abstracts the underlying multi-supplier and silo data systems environment and enables the delivery of an integrated solution that is focused on core policing processes.

This design extends the life of externally supplied services and interfaces that are still used to access the required data. The design also achieves transformation of the resulting output for new and innovative purposes to do with measuring performance effectiveness. This element of the architecture has considered and expanded upon the basic SOA service models presented by [7] and [10 op. cit.] by adding an OLAP index that adds entity aggregation for new reporting of Intelligence issues using data tables extracted via web services from existing data sources.

The web services provide a controlled and manageable framework to support the interaction of proprietary interfaces. This is particularly relevant within the context of the business environment, where this architecture is being applied, due to the growing number of third-party systems. Some of these systems limit access to underlying data by the use of proprietary web services. A common situation is emerging throughout the Police Service where external suppliers limit access to underlying data systems through their interfaces based on Service Level Agreements and contractual restrictions. Readily-adapted web services that re-present the underlying functionality of proprietary systems allow an evolutionary path for source system replacement. This adaptation is achieved by scripting some business logic into the supplier's web service or interface. Furthermore, the extent to which scripted business logic is required or permitted within the confines of a third party supplier environment will also vary across different processes and systems. The ability to define

these interfaces is a core consideration and feature of this architecture.

## 5. 'Closing the loop' on Performance Management

From a national strategic policing perspective under the emerging ISS4PS there is a reluctance to promote any additional On-Line Analytical Processing (OLAP) data manipulations without first assessing any resulting On-Line Transaction Processing (OLTP) solution. However, this reluctance is predicated on the vision of delivering a pure 'green field' solution that will hold all police data centrally, and does not address the economic need to reuse existing investment in multi-supplier systems.

To close the loop between data collected and performance measured, an analytical indexing service based on an underlying OLAP data structure assembles the performance dimensions of: activity reference number, activity status, date ranges, type codes, geographic locations, teams and individuals (see Figure 2). The indexing of core business activities to assemble these performance data represents entity aggregation rather than process integration, and offers a route for consistent performance measurement in a multi-supplier environment where upgrades or replacements occur.

This approach will reduce the volume of data to be held and synchronised within the OLAP index, whilst still providing a level of efficiency when analysing the data for Performance Management.

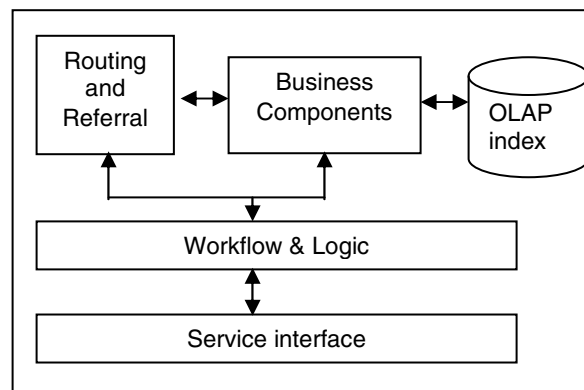


Figure 2. Analytical Indexing Service Model

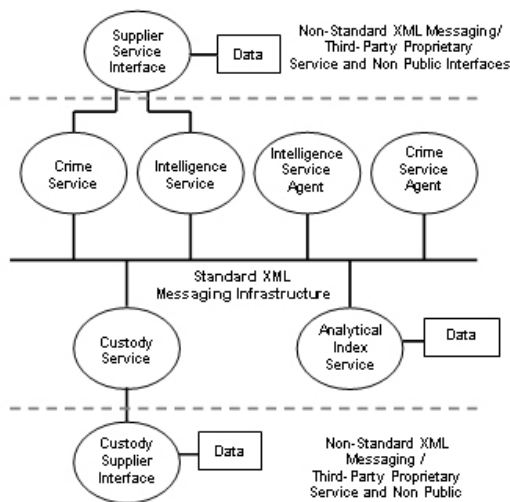
## 6. A Prototype Development to Test the Architectural Concepts

The aim of this prototype is to evaluate the potential to direct and focus the longer-term strategic technical

vision and to test if the infrastructure is scalable and capable of delivering the future development of data access and integration within the Force.

This prototype development achieves the integration of custody data with both a potential crime and also an arrest report as the intelligence recording process. This provides the opportunity to validate the design from the perspectives of both Performance Management and criminal intelligence gathering. The architecture, with a technology mapping, is in Figure 3.

The crime and custody systems have been adopted widely throughout the Police Service; eleven other Forces have implemented the same crime system and twenty three Forces the same custody system [8, op. cit.]. However, both the crime and custody system have limitations on the access to and availability of performance data, and lack any detailed functionality to support this activity. The two systems are from separate suppliers and do not have any capability to communicate or share data for intelligence and analysis purposes.



**Figure 3. Custody, Crime and Intelligence integration across proprietary edges**

In this proof-of-concept prototype, the web services are constrained to access and update the three key business areas of Crime, Intelligence and Custody. The needs of Performance Management within the Force require access to data that represents the seven dimensions of business activity: primary reference number, activity status, date ranges, type codes, geographic locations, teams and individuals.

To provide the new analytical indexing functionality, a database has been developed to hold

the fact tables relevant to the OLAP data for Performance Management.

The SOA model demonstrated by the prototype has now been adopted by the Force as its strategic model for data access and integration. A formal development project has implemented the first stages of the solution in a live production environment with considerable success and clear business benefits particularly in the area of criminal intelligence. The solution has been subject to formal external scrutiny by the National Police Improvement Agency who has commended the project as a service leader that aligns to the national policing vision and is capable of delivering real business benefits [12]. They locate the implementation as 'standardised', level 2 of the Microsoft 4-level SOA maturity model [18].

## 7. Discussion and Conclusions

This paper presents the contribution of an overarching and holistic technical architecture aimed at resolving the data access and integration issues of an existing multi-supplier and heterogeneous infrastructure commonly found throughout the Police Service.

The example solution is implemented alongside existing systems and demonstrates the challenges and complexities faced within a live policing environment. The design and resulting solution delivers a scalable software prototype that presents the architecture framework as a capable guide for the longer-term strategic and technical vision of the Force and as an implementation model to deliver the future system and data integration needs in a consistent way.

The architectural design focusses on the operational needs of the Police Service and the issues relating to the contractual obligations and supplier protocols for accessing and retrieving data from numerous disparate source systems. The result shows it to be both financially and strategically unnecessary for a non-profit organisation such as a Police Service to replace all of its source systems with 'new' SOA compliant solutions.

During this development, it was found that some compromise was needed to be made to ensure the resulting Web services exposed sufficient functionality of the source system to achieve the desired outcome.

The common CP-XML schema specification, although unique to the Force, is central to the architectural design and ensures that both structured and unstructured data can be logically represented. This CP-XML specification, when applied to additional systems, offers additional integration across a disparate multi-supplier environment through a

formal approach to entity aggregation. The policies and procedures given here will need to be enhanced to ensure the acceptability and effectiveness of the CP-XML specification and a robust approach to any proprietary data mapping in order to minimise the potential for semantic dissonance.

The Force's current primary data analysis is a central data warehouse, which is tightly coupled to the complexity of accessing proprietary transactional source data. However, many difficulties surround further development and maintenance of the data warehouse solution due to the tight coupling of data extraction, hindered by complex system logic and data standards. The architecture presented here is a solution to overcome these issues by employing partial replication by data aggregation in an On-Line Analytical Processing database (OLAP) with an analytical index. The index is implemented by holding a much smaller dataset than the data warehouse and is assembled from a given business activity. This approach minimises any unnecessary impact on operational policing, whilst providing access to timely and accurate data about performance

Finally, the National Policing Agency has reviewed the implementation of this 'proof-of-concept' project and commended its use of existing infrastructure assets, its focus on operational benefits and its modular implementation of appropriately abstracted loosely-coupled services that support composable solutions. They rate the implementation at level 2 of the Microsoft 4-level SOA maturity model.

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