

Viseon Clinical Informatics Components

Park Street Solutions Company

INTRODUCTION

As a consequence of constant changes in regulations, payer requirements, and market pressures, hospitals face constant demands to organize the processes of medical care and administrative services ever more economically. At the same time they face enormous pressure to improve the quality of care provided to patients and to assure patient safety in the hospital environment. Hospital management is obliged to harmonize these conflicting objectives through intelligent organization, advanced leadership concepts, and modern software technology.

An integrated, longitudinal patient information database specifically designed to support clinical data analysis is an essential tool in addressing these challenges. Park Street Solutions Company has created the Viseon line of knowledge-model driven components to support the construction of advanced clinical data warehouses. Clinical data repository (CDR) solutions based upon Viseon bring together structured and unstructured data from a large number of sources within the enterprise to create a single source of reliable, unified, up-to-date patient data. Viseon CDR database systems allow clinicians, researchers and management to quickly develop actionable knowledge.

The Viseon architecture incorporates the best in modern data warehouse design practices, along with Park Street's advanced knowledge modeling technology, to create a highly sophisticated solution for clinical data management.

KEY CONCEPTS

Viseon organizes patient data for reporting and analysis and presents it from a clinical point of view. The central data architecture of Viseon is patient-centric, based on the concept of a single, longitudinal patient record. Differing perspectives on the patient encounter which originate in multiple source systems are mapped into a single, clinically-oriented Patient-Episode-Visit structure.

Unlike financial and operational data warehouses, which are designed to support summarizing units and dollars, Viseon focuses on detecting complex combinations of data elements, counting and ratio problems, and statistical analysis of variance, covariance, and correlation. Viseon represents the highly disparate events in the patient record as a single event stream, rather than as an interlocking collection of additive series of facts.

Importantly, clinical data is characterized by substantially more complex structures and systems of classification than typical financial data. Robust knowledge organization schemes like SNOMED, LOINC, CPT-4, ICD-9 and ICD-10, MESH, and Gene Ontology are used to characterize patient event data, along with organization charts, location maps, and other institution-specific structures. The Viseon architecture responds to this requirement by incorporating Park Street's advanced knowledge-modeling technology, allowing complex structures to be defined, maintained, and traversed efficiently.

Because clinical data describes a wide variety of real-world events and observations and it is gathered from multiple systems and sources, Viseon has been designed with an open content model in mind. Repositories based on Viseon can accommodate the widest variety of data and support the addition of entirely new dimensions without requiring alteration to the core database schema.

The Viseon architecture is designed to be HIPAA-aware from the outset. It is comprised of two physically distinct databases – one which is fully compliant with HIPAA rules for de-identified patient data, and another that stores Protected Health Information in encrypted fashion. Only users and applications with the rights to do so can explore the PHI database or join data from the two databases. Additionally, Viseon is designed to allow permissions-driven and role-based control over access to clinical data, and it includes facilities to track the history of data access and usage.

KNOWLEDGE BASE

Park Street's core technology is database software called ONTX that supports the construction of sophisticated knowledge bases. It is uniquely well-suited for use in hospital and other corporate applications because it is the only knowledge modeling system that uses relational database technology to store and query the knowledge base. Relational database systems are the dominant technology for managing enterprise data: all major hospital information systems are based upon relational databases, and almost all software developers and system administrators are trained in their use. That means that ONTX knowledge bases can interact seamlessly with existing data and computer systems, and can be easily used by technical staff without adding an additional layer of complexity.

Viseon is designed around an integrated knowledge base driven by ONTX. All dimensions (other than the patient visit dimension) are modeled as knowledge structures within the knowledge base. That means that structures and relationships within dimensions, and among dimensions, are represented robustly. Advanced classification structures (such as the SNOMED poly-hierarchy or the UMLS Semantic Network) can be represented and used to classify patient event data. Organizational trees – networks representing processes or protocols – mappings between different coding systems (or from current to previous versions of coding systems) – all can be represented efficiently in the knowledge base. And these structures and relationships can be queried and traversed efficiently using standard SQL, allowing a range of tools and applications to interact with the Viseon CDR.

The use of the knowledge base means that all dimensions are “soft dimensions” – that is, they do not affect the database schema for the underlying event facts. Because dimensions are modeled in the knowledge base, events in the patient record can be associated with any number of dimensions, and with any given dimension any number of times. New dimensions that accommodate new event types can be added simply by adding to the knowledge base, with no requirement that existing patient data be “converted” to a new structure.

DATA ACQUISITION

Given the multi-system nature of almost all hospital IT architectures, a substantial volume of information is typically exchanged between systems in real time. This data flow provides richer and more robust information about the sequence of patient events than any traditional snapshot extract could. Viseon is therefore architected around real time data acquisition. A message-queuing architecture is employed to manage the flow of information through the Viseon CDR's data acquisition, transformation and loading processes.

Use of HL7 formats for real-time data exchange is becoming increasingly common. Viseon includes extensive features for HL7 message capture and translation. Other, non-real-time approaches to data acquisition are supported through Park Street's complete ETL systems. Park Street's tools can poll for data availability; proactively acquire data using FTP, HTTP, or file copy operations, or passively receive FTP transmissions or file copies; and query databases for data on a scheduled basis.

ADT TRANSACTION MANAGEMENT

Precise information regarding patient status and location is crucially important in understanding the meaning of clinical events. For example, the same laboratory test results might have significantly different meaning depending upon whether the test was administered during the Emergency phase of an encounter or during one of a recurring sequence of Outpatient visits.

The flow of Admission, Discharge, Transfer, and Location Change (ADT) transactions therefore provides a crucial “lens” through which clinical event data can be viewed. Viseon is designed to capture ADT transaction flow in real time and to build a map of the patient encounter in terms of encounter phase and patient location. These maps are used to enhance patient event data as it flows into the Viseon CDR.

An additional problem results from the reimbursement-oriented nature of the Episode and Visit structure found in raw patient event data. Viseon analyzes the ADT flow to construct a clinically relevant episode and visit structure and to build a map from raw incoming data to this structure. Patient event data can then be organized in a way that is clinically relevant.

EVENT CLASSIFICATION AND ENHANCEMENT

Patient event data must be reformatted as it passes into the Viseon CDR. Using the mappings developed as part of ADT management (described above), each discrete patient event is enhanced with information describing the encounter phase and patient location at the time of the event. The event is also associated with the appropriate clinical encounter and visit.

Each patient event is associated with a principal classifying node in the knowledge base. For example, an event representing the assignment of an ICD-9 diagnosis is associated with the appropriate node from the ICD-9 knowledge model in the knowledge base; an event representing the administration of a laboratory test is associated with a taxonomy of possible tests.

Many events contain additional detail that is particular to the event type. Laboratory tests, for example, include information regarding how the test was ordered. The Viseon architecture provides for storage of secondary facts regarding events while providing a single repository recording the events themselves. Sometimes events reference unstructured data or other resources that are external to the Viseon CDR. A radiology order, for example, might reference images captured during the administration of the test. In this case, an event indicating the existence of the external resource is stored in the Viseon CDR; the reference itself can be followed to view the resource itself.

Finally, the event is prepared for posting by forwarding it to a queue. Real-time elements of Viseon can be implemented by reading and posting events from the queue as they occur. More commonly, events will be read from the queue on a scheduled basis (generally daily) and loaded into Viseon during low-usage hours.

NATURAL LANGUAGE PROCESSING

History and physical reports, progress notes, discharge summaries, and other textual reports represent a vast repository of patient data that generally goes unmined. A variety of commercial and open-source Natural Language Processing (NLP) engines are available that can analyze text and extract clinical concepts. But there are special complexities involved in working with data obtained through NLP. The Viseon architecture is designed to accommodate NLP data seamlessly.

Information obtained using NLP is associated with a degree of certainty. Textual reports often express clinical findings with qualifiers such as “signs of”, or “possible”, or clear statements of negation (“no signs of”). Viseon supports the association of a degree of certainty with each patient event. Because concepts of certainty and negation are modeled in the knowledge base, sophisticated notions of modality can be incorporated into Viseon queries.

Another challenge of NLP data lies in the fact that all of the subtleties of human language are employed in textual reports. When concepts from SNOMED (or a similarly robust modern ontology) are extracted from text, any of several hundred thousand highly granular concepts may be produced – but meaningful clinical analytics usually operates at a much higher level of granularity. The upshot is that it is only possible to make sense of NLP data when the complete source ontology, including all of its structure and relationships, is available in the analytic system. Because the ONTX knowledge modeling system is incorporated into the Viseon architecture, advanced analytic applications that merge NLP data with other clinical facts can easily be built.

THE PROBLEM OF TIME

Clinical analysis requires the ability to investigate time-based relationships between facts. A related requirement involves the need to be able to identify intervals where a certain condition is true (“The Clinical ‘While’”). Time-stamped data by itself is insufficient to meet these requirements, and the SQL language does not provide efficient, convenient support for identifying intervals of time.

The Viseon architecture includes sophisticated support for the temporal aspects of clinical informatics. State-machine driven tools are provided to transform event streams into repository-resident maps of patient state over time. SQL extensions allow queries to perform logical operations upon state maps and generate composite maps, and to identify relevant intervals within a state map. It is then possible to join interval sets with patient event data elsewhere in the repository (or even to data outside the repository) using standard relational capabilities.

GENOMIC DATA

Genomic science has the potential to fundamentally transform the practice of medicine. The advent of genomic medicine will allow physicians to predict vulnerability to disease and response to treatment, personalize prevention and treatment strategies, and preempt disease before symptoms and damage occur. It is anticipated that genomic science will drive changes on the scale of the introduction of antibiotics and aseptic surgery.

The data associated with genomic science is extremely complex. Knowledge base structures such as the Gene Ontology are required to organize, manage, and query a large database of personal genomic data. Viseon's built-in knowledge base technology provides this essential foundation, and since Viseon uses its knowledge base to represent and classify all patient data, Viseon provides a common representation for both genomic and clinical data. Viseon is uniquely capable of supporting applications and analyses that require the integration of these disparate data types.

The addition of genomic techniques to the practice of medicine will multiply the level of knowledge needed by physicians and data analysts. Publicly-maintained ontologies and knowledge bases will be enhanced to describe both genomic data itself and the interrelations among genomic and clinical concepts. Viseon's integrated knowledge base offers a single representation for the multiple, interlinked knowledge bases that will arise as genomic science develops.

DATA WAREHOUSE QUERY CAPABILITIES

Viseon is designed to support direct queries from a variety of different application types: report writers like Crystal Reports, business intelligence/OLAP tools, data mining and statistical analysis systems, or custom-built applications. Because Viseon uses relational database technology throughout, almost any off-the-shelf reporting and analysis tools can be used with Viseon CDR systems.

The Viseon architecture includes a framework for information presentation called CDR Explorer. The CDR Explorer user-interface is designed to support point-and-click navigation of knowledge base structures, presenting a simple dashboard-style graphical interface to users. Viseon also includes Park Street's Riveon tools, which provide an easy-to-use platform for self-service ad hoc queries based upon knowledge structures.