An Integrated Information Architecture for Rural Emergency Medical Service Systems

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Abstract

Rural emergency medical service (EMS) systems presently handle over 12,000 patients per day in the United States. Every patient encounter is information intensive and the capture, processing, and storage of this data is a costly part of the health care delivered. Present approaches for dealing with pre-hospital information are fragmented and unstructured. However, a confluence of existing and emerging technologies offers an opportunity to deploy an integrated information architecture to address the needs of rural EMS. This paper traces the historical evolution of rural EMS information architectures and proposes an improvement based on existing and emerging technologies.

INTRODUCTION

The provision of medical services in the pre-hospital environment is an information intensive activity performed by Emergency Medical Service (EMS) systems. Since their inception over two decades ago, the information architecture associated with EMS has undergone significant changes. The term "EMS information architecture" is here meant to define the communication and computer systems that manage and manipulate information generated in the pre-hospital environment. These have always involved mobile communications as a core part of the architecture. Of special interest is the provision of emergency medical services in rural areas. As many as forty percent of the medical emergencies in the United States occur in "rural" areas. For the purposes of this paper, any area lying outside one of the traditional Standard Metropolitan Statistical Areas (SMSA's) is considered rural. Unlike its urban counterparts, the "rural" EMS system must deal with a service area that possesses large variations in population densities, wide geographic separation of receiving hospitals, and meaningful numbers of patient transfers to facilities outside its primary service area.

Rural EMS delivery systems have existed for over two decades in the United States. Prior to 1970, emergency medical service was provided by a spectrum of entities including funeral homes, garages, and hospitals. Because of this association with federal largesse, EMS was viewed in the 1970's as a

"public service" rather than as a part of the health care industry. During its second decade of existence EMS, with the demise of federal funding for system development and expansion in the early 1980's, began to make the painful transition to a market driven environment. As a result, entering its third decade in 1994, most successful rural EMS operations of the 1990's are based on market driven, fee-for-service models. The shift in rural EMS from a public sector, cost-center model towards a quasi-private sector, profit-center model has driven the evolution of information architectures deployed by rural EMS systems.

The discussions of information architectures for rural EMS systems here will follow the historical pattern. First, there will be a perspective of the "past", the decade from 1974 to 1984. Second, there will be a description of the "present", the decade from 1984 to 1994. Third there will be a projection of the "future", the decade extending from 1994 forward. In each case, the design requirements, the system implementations, and performance constraints of the information architectures will be reviewed. The orientation for review will address information as its relates to the operational, business, and medical aspects of EMS

THE PAST IN RURAL EMS

With the enactment of the EMS Systems Development Act in 1974, rural EMS delivery began an evolution from an *ad hoc* component of public safety agencies to a systematic entity for prehospital medical care. A guiding theme of the first decade was to provide rural areas with universal access to standardized protocols of prehospital care. Rural EMS systems operated as two-tier systems of care: Advanced Life Support (ALS) treatment in a mobile environment to deal with life threatening situations and Basic Life Support (BLS) treatment to deal with medically necessary, routine transport of patients. EMS was challenged to develop and deploy protocols and interfaces to the larger health care system.

Past Requirements

Requirements for information architectures in rural EMS systems may be logically divided according to the source and or use of data. Thus one may address business data, operational data, and medical data. The artifacts used to implement the requirements are traditional paper forms, mobile telecommunication systems, automated data processing technology and the protocols integrating these elements.

In the first decade, requirements for the business data processing were minimal. Many rural EMS systems were operated by public agency cost centers and did not bill patients. Insurance carriers were slow in establishing reimbursement procedures. Business data processing and

billing remained a system of little concern to rural EMS.

The requirements for operational data and data processing were driven by PL 93-154. One, there had to be a wide area mechanism for reporting or accessing the rural EMS provider. Two, there had to be a means for controlling or dispatching the emergency vehicle fleet in a mobile environment. Third, there had to be a systematic capture for retrospective analysis of the operational parameters associated with each run or service call. The dataset of operational parameters was undefined except to the extent that such data collected could be used to demonstrate adequate access and response times.

The requirements for medical data were driven by the medical practice acts of the separate states in general and the paramedic enabling legislation in particular. A key concept was that of medical control. Under requirements promulgated by DHEW and many state medical practice acts, physicians were always to exert direct, real time control of paramedics in the field. Documentation and data from the field needed to demonstrate medical control and care coordination while describing the time sequence of treatment procedures and patient vital signs.

Past System Implementations

The business data processing cycle of most rural EMS systems was *ad hoc* and viewed as a nuisance. Reporting was accomplished by 911 systems in areas with population concentrations and by area wide 1-800 numbers for sparsely settled areas. Centralized dispatching was implemented using VHF in the 155 Mhz band. Care coordination was to be implemented using a separate UHF (SERS in the 450 Mhz band) system that supported full duplex operation and EKG telemetry. Medical control documentation was based in large part on the Standard Patient Report developed at the University of Pittsburgh that provided a comprehensive operations dataset, prehospital medical dataset, and forward/backward links into hospital emergency departments. Batch analysis of the Patient Report form constituted the operational evaluation.

Past System Performance

Wide area 1-800 numbers proved impractical to market so much reporting in rural areas depended on cross band links with criminal justice and other public safety agencies. Despite occasional channel contention and skip problems the 155 Mhz band VHF systems proved inexpensive and adequate in the dispatch role. The separate UHF system for care coordination and medical controlled proved unworkable and, in the end, unneeded. The cost coverage advantage of VHF was four to five to one over that of UHF. Rural systems could not afford the UHF systems. Although they received relief from the FCC to employ 155 Mhz VHF systems for EKG

telemetry, most rural EMS systems had long since shifted to standing orders for medical control by the early 1980's. The Patient Run Report developed at Pittsburgh with minor local modifications was widely deployed and served as the basis for a uniform prehospital medical record.

THE PRESENT IN RURAL EMS

With the demise of virtually all federal support for research and development, rural EMS delivery, beginning *circa* 1984 evolved from tax supported agencies of local government into market-driven, quasi private providers of prehospital medical care. In this second decade, because of the lack of public resources, rural EMS developed a variety funding sources including third party payers and various subscription strategies. Rural EMS systems, in an effort to optimize cost and quality of service, moved to single tier systems of care. For reasons related to cost, quality, and levels of third-party reimbursement all ALS(Advanced Life Support) became the norm. Now as a full partner of the health care system, rural EMS experiences many of the same management and policy problems as does the larger health care industry. The aging of the population continues to escalate the demand for services. The highly litigious nature of the general society requires greater emphasis on service quality and patient documentation. The requirement of EMS systems to provide emergency service on demand without regard for the ability of the patient to pay in a population that is increasingly under-insured or uninsured places great stress on the operational aspects of financial management.

Present Requirements

In the second decade, requirements for business data processing were expanded significantly and tied directly to the prehospital medical record. To effect patient and third-party billing, it was necessary to capture complete financial data, to demonstrate medical necessity, and to automate the billing cycle. The reporting requirements were usually met by the arrival of enhanced 911 systems. The dispatching function embraced a more expansive role involving arrangements for institutional transfers, payment processing, and resource allocation. From a logistical standpoint dispatchers were required to validate institutional arrangements in all patient transfers and with the business office/function arrange payments for non emergency transfers. From a fleet standpoint, dispatchers were expected to provide system status management so as to meet performance targets within existing system resources. The requirements for medical and operational data were increased to address the ever present threat of litigation, the need for quality assurance, and the demonstration of necessity. Care coordination required extensive documentation and review for appropriateness.

Present System Implementations

The business data processing cycle of all rural EMS systems, taking advantage of the microcomputer revolution was automated. Reporting was accomplished by enhanced 911. Centralized dispatching continued its reliance on earlier VHF systems in the 155 Mhz band augmented by local cellular systems. For larger rural systems Computer Aided Dispatch (CAD)systems were deployed. Care coordination was handled by standing orders. Medical control documentation was expanded and the state reporting requirements for both operational and medical data exploded. Every region or state sought to define its own unique prehospital medical record based on a paper model.

THE FUTURE IN RURAL EMS

With the pending reorganization of health care delivery in the United States likely to begin in 1994, rural EMS is due for yet another major shift in medical and financial paradigms. While the nature of health care reorganization is yet to be debated, rural EMS ,in its third decade, can expect significant changes in funding and delivery mechanisms. A likely funding mechanism is a shift from multiple payers on a fee-for-service basis to single payor, single payment reimbursement tied to demographics. The role of personnel and the menu of medical services offered will also change dramatically. In rural settings without hospitals, EMS may emerge as major player in primary care and preventive health programs. Patient documentation and linkage needs will explode and the pressure to optimize the cost of production while maintaining quality will be dominant.

Future Requirements

First generation rural EMS information architectures could be characterized as an attempt to observe the system, second generation as an attempt to control the system, and the next generation as an attempt to optimize the system. Reporting, although generally implemented by enhanced 911 technology, will have to accommodate increasingly larger service areas as the aggregation of rural EMS providers continues. Whether operating under a market driven or managed competition motif only the strong will survive. This will dictate the real-time integration of business constraints, operational data, and patient medical data for decision making. The logistics of what is now termed "system status management", now simplified by single tier delivery systems, will have to incorporate the concept of "economic dispatching" in a multiple tier service environment. The current concept of the prehospital medical record as defined by various state regulators will have to be expanded to include intelligent mechanisms to gauge the necessity and appropriateness of care

protocols while incorporating electronic portability. The information architecture of the coming decade in rural EMS must integrate all medical, economic, and business data while allowing ubiquitous access for machine-aided decision making by those closest to the delivery of services.

Future Info Architectures

Previous information architectures in rural EMS could fragment the business, operational, and medical data. That fragmentation is no longer allowable. Because of the nature of data involved, the following platform needs exist for the next generation system. On the communication side there is a need for a ubiquitous, broadband mobile capability. At least the system should allow some dynamic allocation of bandwidth. On the computer side there is a need for a multimedia data repository with distributed access from either fixed or mobile sites. The means of data capture should be highly automated and occur as close to the source as feasible. The supporting software must include intelligent decision making aids for vehicle/resource deployment over time, appropriateness of medical procedure, economic dispatching, and documentation extensions in higher risk procedures. Depending on the new paradigm for health care the decision making on economic dispatching and appropriateness of care may require access to data created by other health care providers.

The inexorable march of technology now places many of these capabilities in reach. The Motorola Iridium and other competing approaches should make available with utility pricing in this decade a ubiquitous mobile telephony capability for rural EMS that integrates terrestrial and space cellular seamlessly. The economies-of-scale in the broader computer market make local-area-networks (LAN) an attractive means for enterprise wide, missions critical applications if reliable, broadband communications can be obtained in the mobile environment. Relational database technologies now exist for multimedia data management on the platforms of choice. Neural network technologies afford a new, heuristic decision tool of great promise in health care.

The key driver of this this integrated information architecture, however, are the new paradigms for health care delivery emphasizing managed care with life cycle costing. Although the shape of these paradigms remain to be determined it is reasonable to expect that by 2000 the rural helath care delivery system will be an integrated one in which EMS will assume some of the tasks associated with primary care. The information architecture for rural EMS accordingly must become integrated and support decision making with the totality of system and patient data. The architectural requirements overviewed here are structured in that direction.