Health Care Service Iconography: Advancing Medical Record Lucidity Through Intelligent Iconography

WILLIAM M. BEVINGTON, PIIM
& DAVID FUSILIER, PIIM

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ABSTRACT An analysis of paper medical records systems reveals a neglected metric for improved Workflow and Navigation in the design of Electronic Medical Records (EMR) Graphical User Interface (GUI) systems. This metric, the healthcare service event, failed to make a meaningful transition into the contemporary EMR GUI workflow. Current electronic systems typically follow a primarily task-based structure: dividing content into case-by-case selected activity modules, i.e., Vital Signs, Medications, Labs, etcetera. In contrast, paper medical records systems, like real-world professional practices, follow a primarily event-based structure: grouping content according to healthcare service events, i.e., a physician encounter, a diagnostic procedure, a surgery, etcetera. Designers of contemporary EMR systems would benefit from a unified taxonomy that seamlessly integrates and structurally supports both event-based and task-based logics. Our proposal for achieving such a system requires a bridging device which we refer to as intelligent iconography. This will result in the effective integration of content representation and its control through a unified taxonomy for a superior EMR GUI workflow.

Intelligent icons, specifically designed for an integrated EMR GUI, require a proprietary taxonomy, ontology, and manifest. Taxonomy refers to the categorical and principle divisions to be represented through intelligent iconography; ontology determines how each taxonomic element is defined; manifest provides for the explicit visualization of the intelligent icons. Through these considerations, this paper presents a fully articulated set of intelligent icons herein referred to as: Health Care Service Iconography (HCSI).

FIGURE 1: Health Care Service Iconography (HCSI) provides the gateway to a next-generation electronic medical records graphical user interface through its multi-purpose capability. The intelligent icons serve as informed representational devices that provide healthcare professionals with rapid insight into the healthcare documentation collections. These can be placed in various contextual arrangements, providing holistic insight.
INTRODUCTION
Why would a document dealing with electronic medical records express such concern for their obsolete predecessors: lowly paper records? It appears that one would only gain in a transition from fixed paper documentation to free-floating data points buildable into myriad views on a EMR GUI.

However, an analysis of paper medical records systems reveals an elegant underlying logic born out of centuries of refinement. In short, a clear distinction is made between the documentation which travels with the patient from encounter to encounter and the documentation which does not. Both of these types are involved in the healthcare service event, the basic metric of traditional healthcare provision record keeping. Additionally, records were distributed through topically tabbed dividers according to several organizational logics. Early forms of EMR systems utilized views of digital capture of such records—these systems provided input, storage, and output, but no manipulation. Heuristically, such systems accelerated the “find” aspect of the healthcare provider’s workflow while maintaining the event-based orientation built into the structure of their paper forerunners.

As electronic medical records advanced, every specific data point (previously imprisoned in static documents) could be now be distributed into a database structure. Once in columns and rows, all data could be organized into discrete categories. Many EMR GUIs are designed for this purpose—by discrete activity categories—resulting in a task-based orientation. In this paper we argue that this over-simplification creates a workflow problem. Irrespective of whether one is in an event-based or task-based medical records system, representational methods are required to identify and control operations of data selection. This representation is usually accomplished through textual or iconographic identifiers (text on tabs or control buttons). Once data sets have been effectively grouped into their component types, a graphical representation, such as a discrete icon, can be assigned to such categories. Although any GUI could be handled without the use of icons, these representational symbols are common in EMR GUI design because they serve compact control and orientation functions, and, through familiarization, cognitive improvement. In a task-based system (being essentially an extensive series of nodes) simple icons can act only as one-dimensional proxies for equally singular concepts or things. For this reason, the typical state-of-the-art EMR GUI can only benefit minimally from a reasonably well-designed icon set—such as through representation and alert functions.

In contrast, consider the event-based system with respect to icons. Simple icons are insufficient for the representation of a multi-task event. The composite nature of a service (being made of variable and varying task sets) requires a more sophisticated visual representation. An objective in the design of a more advanced EMR GUI is to find a shorthand method of overseeing collections of healthcare service event records. In this case, an intelligent icon is required. Intelligent icons convey multiple levels of information, usually through a contextual “build.” Intelligent icons can easily represent the multi-dimensional depth of a healthcare service event and convey specific levels of information inherent in any particular data set, as well as visual summaries of content. This ability allows for a next-generation workflow environment that matches the real-world healthcare practice. Intelligent icons will leverage typically unrealized EMR capabilities for a far more effective healthcare provider user experience. Intelligent icons effectively deliver spatial navigation capabilities as opposed to mere linear or drop-down type navigation.

The advantages of using intelligent icons continue beyond their advanced representational and content revealing capabilities. Once a user becomes familiarized with a set of intelligent icons, the knowledge that they convey can then be placed in multiple contextual schemas. Therefore, intelligent icons assist workflow not only through the cognitive gain which may be ascertained through their deployment in their representation of collective records, but through their arrangement in a graph, table, or on a map.
Little can be expressly quantified when it comes to the consistent division of documents within paper medical records, but several factors can be said to prevail. A first prevailing factor includes a self-evident division of records into two data document types. We refer to them as event-specific and event-spanning documentation. The first type is a document specific to a particular health-care service; the other is a cumulative document, such as those that chart juvenile growth over time. In paper medical records, each documentation type is isolated from the other into discrete pages. This accommodates the unique life cycle of each page type.

**EVENT-SPECIFIC DOCUMENTATION**
If a form can remain grouped with the rest of the documentation involved in the same service event, we refer to it as event-specific. The reason for this classification is that the diagnostic value of such documents are generally limited to the service event in which they are created (highly contextual). Admission Documentation, SOAP

**FIGURE 3:** A typical example of Event-Specific Documentation:

This form is tailored towards the “Objective,” “Assessment,” and “Plan” sections of a Subjective/Objective/Assessment/Plan (SOAP) note.

**FIGURE 4:** This matrix set illustrates the chronological groupings of events that support Event-Based Logic. There are two principle divisions: 1) event-specific documentation (Event 1, Event 2, etcetera) tracking multiple tasks performed during a single event (Tan: Problems & Conditions, Vital Signs, etc.), and, 2) event-spanning documentation (Blue: Problems & Conditions, Vital Signs, etcetera) tracking a single task performed during multiple encounters. This matrix emulates the paper medical record system.

**Tan Section:** Event-Specific tasks are collected together under rows of events. This arrangement allows clinicians to ascertain a holistic, and fairly rapid, understanding of a patient’s condition at any given time. The matrix illustrates how events in chronological sequence collect each concurrent task. The user does not navigate through modules of tasks, but through collections of tasks filed under a single event.

**Blue Section:** Event-Spanning tasks are collected under columns of their specific type. This allowed healthcare professionals to monitor changes over time for discrete issues. These paper forms “traveled” from previous events to most current event as needed (e.g., Event 6 includes five event-specific tasks and the entire set of event-spanning documentation).

Because of the limitations of physical records, task recording is duplicated between event-specific and event-spanning documentations. For example, Vital Signs are recorded during each event and compiled in a separate “traveling” event-spanning document. This redundancy provided valuable insight, as physicians understood a patient statistic in both the context of the current event and in relation to every same statistic in every other previous encounter (The diagram denotes this linkage via the yellow highlighted box).
Notes, Physical Examination Forms, Impressions, Dispositions, Orders, and Waivers are all examples of forms unique to the event-specific documentation type. These documents, being unique to the event-specific data type, are essentially qualitative. They were kept singularly with other event-specific documentation.

**EVENT-SPANNING DOCUMENTATION**

In contrast to event-specific documents, event-spanning documents are essentially quantitative. If a document “travels” from a previous encounter’s documentation to the current encounter’s documentation (as necessary), we call these documents “event-spanning.” The reason for the traveling nature of event-spanning documents is that they are widely relevant to multiple services (context independent). In order to permit such paper documents to travel, they must be duplicated, so that they accompany any set of any event-specific documentation they need to. Event-spanning documents include Vital Sign Graphs and Growth Charts as well as other easily accessible lists, such as an Allergy List stamped on the front of the medical chart. This traveling documentation may be reviewed and updated from encounter to encounter.

Event-spanning documentation contains quantitative and qualitative data collected from multiple event-specific documents. If quantitative, this data is typically either graphed over time; if qualitative, this data is typically maintained in curated-list form.

Event-spanning documentation exists both in electronic and paper medical records systems. However, as stated, in paper systems event-spanning paper documentation is duplicated, allowing a physician to keep both an event-spanning and event-specific record of a task simultaneously.

This duplication is an important part of physician paper documentation workflow. A physician typically notes patient measurements in the event-specific documentation (for instance, noting the patient’s weight in the “Objective” portion of a SOAP note...) before transferring that measurement to event-spanning documentation (...then graphing the weight measurement in the context of previous weight measurements in a Growth Chart). Designers of current EMR GUIs seem to view this duplication of event-spanning documentation into event-specific form as an artifact of paper medical records systems: a data inefficiency mandated by the limitations of physical paper work. Contemporary design practice, particularly within information design, move away from redundancies towards design efficiencies. After all, “less is more.” This is also database practice. But what if seemingly obvious redundancies possessed a hidden benefit?

The impulse to streamline data inefficiencies is not an improper one; however, trouble arises because poorly considered streamlining may alter physician workflow and, in this case specifically, because there is yet another functional purpose to this “inefficient” data duplication. The careful observer will note that data duplication in paper medical records also allows physicians to see patient measurements not only in the context of other measurements of the same type over time, (a task-based orientation), but also in the context of other tasks performed simultaneously (an event-based orientation). In the assessment and treatment of patient conditions both orientations are important to physicians. To permit both orientations the physical limitations of paper medical records mandated a duplication of data between event-specific and event-spanning documentation.

**THE HEALTHCARE SERVICE EVENT**

A second prevailing factor is the grouping of data documentation into healthcare service events, such as: encounters, diagnostic services, surgeries, etc. In the current healthcare provider paradigm healthcare providers live in time. When a clinician deals with a patient or goes

![Figure 5](image-url) A typical example of Event-Spanning Documentation. This Growth Chart compiles both height and weight measurements over multiple encounters.

![Figure 6](image-url) Event-specific and event-spanning documentation types are typically both present in the paper records of a single healthcare service event.
through records, there is a context in which this is done and through which a series of tasks occur. The packaged context of this activity is the healthcare service event. This packaged context of tasks is essentially the ordering logic of traditional medical records. Evidence that physicians consider the “event” a useful metric is threefold: Firstly, the previously-discussed, necessary duplication of documentation to accommodate event-based analysis; secondly, the grouping of event-specific information into event “packets”; and thirdly, the organization of documentation through a tabbing system whose names imply their event-based logic.

**EVENT ORGANIZING PRINCIPLES**

Another prevailing factor is the event organizing principles used within a paper chart’s tab system, namely: grouping of services by similarity of type, or grouping of services by similarity of specificity.

It is evident that the healthcare service event is the primary metric organizing the workflow of physicians once the organizing principles of the medical records folder are analyzed. If real-world professional practices were indeed task-based, folder tabs would reflect alternative naming logics, such as “Vital Signs,” “Height,” “Weight,” “Family History,” “Impressions,” “Problems & Conditions,” “S/O,” and “A/P.” Instead, one finds tabs names such as “Dermatology,” “Pathology,” “Lab Reports,” “X-Rays,” and “MRI/CT/Bone Density.” These tab names are typical, and imply an event-based logic rather than task-based grouping one. Despite other possibilities for paper record event organization, only two are used regularly: the grouping of events by type and the grouping of events by specificity.

**Grouping of Events by Type** Tabs which group similar or identical service events performed on a patient are considered to be grouped by type. Events grouped by type tend to be “Data Collection” or “Intervention” services. The services that are grouped by type are fairly common because they are relevant to a wide range of specificities.

**Grouping of Events by Specificity** Tabs which group service events performed by physicians with similar or identical specialties are considered to be grouped by specificity. Events grouped by specificity tend to be “Evaluation and Management” services or other services which do not have a high relevancy to other specificities.

**ARRANGEMENT OF EVENTS WITHIN GROUPINGS**

The last prevailing factor is the arrangement of events in chronological order within the tabs. The most recent events are given priority (physically placed on the ‘top’ of previous events). This ordering reflects the increased relevancy of the most recent medical history.

**LEVERAGING THE LOGIC**

When all the data spread across these four prevailing divisions is excerpted and placed within an electronic database, these divisions become less restrictive, providing numerous advantages in the areas of data quality, data quantity, interoperability, and accessibility. Therefore, the relationship between the four divisions within paper records is subsumed within an electronic relational database. Despite this, it is still possible to maintain all the advantages of electronic medical records and still leverage a legacy logic of paper records that has been lost in the deployment of contemporary EMR GUIs. This can accomplished, not through the inefficiency of data duplication (as was the case in paper records), but through...
relinking the data toward a more traditional, clinician-oriented workflow logic.

**NOTES ON ELECTRONIC MEDICAL RECORDS**

Our purpose is not to exhaustively rehash the history of the electronic medical records interfaces or their development. We certainly do not advocate a Luddite return to paper documentation. The diverse advantages of electronic medical records systems are well-documented. So many problems have been resolved with contemporary systems that participants in advancing the design of the EMR GUI can hardly be blamed for turning a deaf ear to early practitioners’ nightmare stories of no interoperability between capture systems and the horrendous interfaces of pre-WYSIWYG (What You See Is What You Get) visualization.

Our concerns are chiefly heuristical, specifically under the aspects of what may be referred to as “match.” This term refers to the closeness of real-world practice to toolset workflow. What is important in the early history of EMR GUI design was the divergence between the toolset functionality and the real-world practices within the healthcare profession at that time. This early cleavage, despite the fact that the profession and the toolset practice has evolved in both camps, remains. One argument for the division of workflow philosophy (besides from obvious technical challenges) is that EMR GUI systems are often concerned with the macro (medium-to-large-scale patient-group management and administration) healthcare medical environment. Clinicians “just want to help their patients”—they generally function at micro level (individual patient care).

Oddly, in order to function at both these levels documentation is critical. Therefore, the transition from the paper document to data capture, storage, manipulation,
and output within transitional and current EMR systems becomes a window into the current state of match. From the front-end perspective, these “touch points” are focused on data representation and navigation, i.e. front-end concerns.

**DATA REPRESENTATION AND NAVIGATION**

For our analysis, tracing the transition from paper documentation to electronically captured data deals with the two paths of distinction and integration. Paper documents are distinct documents; they become integrated only in the meta-documentation sense: that is, multiple papers are placed as companions in the same file. In order to create multiple files with shared intelligence, specific papers need to be physically duplicated and distributed into such files. A first step towards avoiding this physical duplication is to use scanned visual captures in the documents in question. Now they can be “endlessly duplicated” merely by making them accessible with their identifying tags.

A subsequent challenge was good identification, so users could land upon the desired image capture during their search. The ostensibly limitless fluidity of grabbing any document through an appropriate search tagging was that documents were no longer seen collectively—even though they were collectively organized through their tags. Obviously, a series of scanned images still have their data “fixed” within the images. Healthcare professionals may have been excited by the advantages in access and searchability, but we argue that they were diminished in the event-based contextual understanding of the records, as they were no longer physically connected to type of physical and contextual relationships that were once ubiquitous.

Another disadvantage of the scan dealt with the fact that poor legibility issues, should they be present, would be preserved through the act of scanning. A next generation of capture was not mere images of documents, but extracted text. The content was still integrated, but it became searchable. This was an advantage for qualitative information, as it was, from a visual perspective, optimized. However, for early quantitative information there were still many challenges regarding graphical representation. Nonetheless, an important step of data extraction had begun, and this permitted pieces of information to be moveable or combinable with other pieces of information within medical documentation (previously isolated into pure topical categories and subcategories). Through EMR advancement, apparent data inefficiencies became subject to deletion—a fork in the EMR crossroads had

**FIGURE 9:** An early EMR GUI supported by an underlying logic of the patient dossier as a single extensible file. Within the file is every event-spanning task and a chronological collection of doctor notations. The concept extended to include aspects of telemedicine, freeing doctor and patient from physical records. The content is vertical, i.e. seen in discrete task chronologies. Duplicative data was to be deleted. At the time of the design of this interface, huge problems remained. Interoperability of hardware, patient privacy concerns, and the need to capture every physician keyboard click as part of the document (documenting even the act of reviewing a document). Real-time documentation was a significant challenge of the time. One of the principle selling points of the system was the stripping away of context and duplication: the system offered a single composite record.
been reached.

As the information could be parsed into true database structures, the underlying logics for how these structures were formulated became instrumental in influencing the workflow of the physicians or healthcare providers who used them. One approach (see image and caption to right detailing an early EMR designed by one of the authors circa 1993) was to extract all data from all documents to build a composite patient profile, usually accompanied by a small supplementary section covering event-specific encounter information. As critical advancements were achieved in EMR GUI systems — including interoperability between hardware systems that collected data, direct entry of data into the system, and more sophisticated relational databases — the taxonomies underlying EMRs grew in scope, but not in their logical underpinnings. The general problems of paper medical records were vanquished. Volumes of paperwork, lost records, poor accessibility between doctors, and the reluctance to create new tabs for rarely performed tasks became some of the problems of the past. The potential value of record duplication was lost because duplicating an exact cell in a database was counter-intuitive. The unintended consequence of streamlining this apparent inefficiency was the erosion of contextual insight provided by intentional duplication. In essence, the paper medical record’s heuristic nuisance factor was providing integrated sub-packets of contextual medical relevancies.

It would seem that despite the myriad inconsistent advancements along software and hardware fronts and the disagreements of philosophical approach in the idealization of electronic medical records, there was one consistent agreement concerning the taxonomy of data collection: that duplication is bad, and that quantitative categorization is good. In essence, the physical links created by the continual duplication of event-spanning data to event-specific documentation were never replaced with corresponding electronic links.

**Figure 10:** The above image shows the primarily task-based structural bias of the VISTA CPRS. Here, a patient profile view is divided by specific task-modules with a chronological data entry associated to each. Other sections have a similar task-based structural bias (referring to tasks as “actions”). The GUI is based upon linear content within topical areas, as opposed to event-based, inter-task analysis. Although VISTA allows great flexibility, it suffers from a lack of an overall organizing framework based on the inherent differences between tasks and events.

**Figure 11:** The above image shows the primarily task-based structural bias of the AHLTA interface. Referencing Mullet, Jihoon Kang critiques AHLTA in a recent PIIM paper: “The AHLTA GUI suffers from structural and logical predicament common in many enterprise systems: ‘The development emphasis was placed on aggregating and expanding feature sets rather than creating and branching off from a coherent and focused system-wide framework.’”
How Intelligent Iconography Supports an Integrated EMR GUI Matrix

Intelligent icons provide a contextual dimensionality that increases insightfulness respecting the overall data. The thrust of this paper is to demonstrate how intelligent icons, when used within the context of an EMR GUI, can increase the utility of such a toolset. In this paper we present a detailed set of profession-specific intelligent icons (HCSI) in combination with instruction to their unique build-out.

Prior to this detailed guide, we digress briefly to outline a hierarchy of intelligent iconography and to describe what the term “intelligent” means in reference to such icons. The taxonomy provided here is certainly not exhaustive, but it is sufficiently comprehensive for our purposes. Four arguments are put forth: first, how an icon fits within the greater context of symbols; secondly and thirdly, the icon devices and the factors that support the idea of intelligence within them; and finally, how many families of such icons can comfortably reside within any particular GUI toolset.

From the visual perspective there are two broad classes of symbols that concern us. One class of symbols possesses intrinsic meanings. By the term “intrinsic” we refer to communicative aspects that are culturally ascribed to them and match, in some way, what we perceive in the world around us. Generally, they take the form of pictographs or icons. As singular forms they are communicative, although they can also be joined together to convey new meanings (as two pictographs are joined to form an ideograph). Specific examples include the wheelchair icon, a deer crossing sign, or the do-not-enter identifier. The other class of symbols derive meaning through their composition, these symbols possess no intrinsic meanings. Examples include simple letterforms constructed from the visual perspective there are two broad classes of symbols.

Figure 12: (Compare to Figure 4 and Figure 8) In this illustration all the tasks which were formerly mirrored in both the event-specific documentation (tan section) and the event-spanning documentation (blue section) are no longer duplicated. This efficiency is accomplished without creating a hierarchy caused by a divided system. (Task-based to the detriment of event-based, or, event-based to the detriment of task-based.) Instead, this efficiency is accomplished through the beneficial integration of both event-based and task-based protocols—neither is subservient to the other. The winner is the EMR GUI user though a heuristic match to real-world workflow: users naturally adjust to the appropriate protocol as they work. The barrier to achieve this ostensibly simplicity is one of design rather than technology. A navigable bridge towards the integration of the event-based and task-based performance can be achieved through visual devices that are simultaneously highly informative and functionally operative.

Integrated Tan & Blue Section: Here the event-specific tasks are conjoined with their related event-spanning tasks. This arrangement allows healthcare professionals to view changes over time as well as full collections of inter-task data within an event.

In order to relate this to navigational methods, consider the following: typically, navigation involved selecting a event or task and viewing the data within that column or row. Therefore, the user must "zero in" on the data of their interest by arriving at data through the selection of both x and y axes, or selecting either axis and moving through the full column or row data.

Intelligent iconography, specifically Health Care Service Iconography (HCSI), permits the viewer to "see" aspects of the x-y crossover points prior to drill down. Once at the first level of drill down, the user can remain within vectors of events or tasks when exploring content. This marries the collected-records workflow advantages of physical records with the speed, accuracy, and data efficiency of electronic medical records systems.
The term "symbol" carries definitions covering a wide range of representation devices, both visual and non-visual. Included within the visual spectrum are symbols that correspond to our physical perception relative to the things we see—these have "stand-alone" informativeness. Examples include simplified pictures, pictographs, ideographs, and icons. A specific example is the skull-and-crossbone ideograph. Here, death, pirates, danger, or poison is derived, instructed, or implied by the symbolic reference to the partial remains of a deceased human. We refer to these kinds of visual symbols as unconstrained symbols.

The other class of visual representations must be used in context to convey meaning, are more conceptual, and do not correspond to visual perception relative to the things we see. Examples include letterforms, character encoding, and simple polygon sets. Morse code notation is a specific example. We refer to these kinds of interdependent visual symbols as constrained symbols.

STAND-ALONE ICON

Figure 13: Stand-alone icons serve a singular, direct, representational function. Sometimes color reinforces meaning, and is associated with the icon, thus enhancing recognition. However, stand-alone icons are usually color-independent.

SIMPLE ICON SERIES

Figure 14: Conceptually, an icon series should be designed with logical consistency and meaning specificity. From a visual perspective, they must be visually distinctive, but consistent in their proportion and design.
ADAPTIVE ICONS: THE MARK OF INTELLIGENCE

Adaptability is the mark of an intelligent icon. When an icon is designed to communicate multiple levels of functional or informational status, and to thus adapt or change depending on the function or supporting data, it may be considered an intelligent icon.

Such adaptive deviations, or signals, could include: general functional parameters (rollover, available, etc.), emergency status due to dangerously high or low levels, or documents that have just become available or require attention. These adaptations are generally handled with color change, or internal pattern variations. Another possible adaptation (although not used in this example) is the subtle modulation of shape, for instance, making an icon bolder.

ICON F-SERIES

The simplest level of intelligence is primarily a front-end capability dealing with status changes, or function (hence the title “f-series”).

In front-end, function-only distinction, once a set of icons are designed a protocol for the indication of consistent status change across the full series of icons may be assigned. For example, they may need to be brighter during roll-over function, or grayed back when inactive. Icon f-series devices generally function as a control to open windows that permit drill down under a specific category, or they function as warnings or indicators of a change in status. The important distinction is that the color change does not indicate contextual deviation of the represented content. A specific way to differentiate icon f-series from their more advanced intelligent brethren is they are not generated from a connection to a content database. They are strictly front-end devices. Note: If function is generated from a database, it is not of this class (see d-series).

ICON D-SERIES

A far more advanced form of intelligent iconography is the “d-series,” or data series. These forums are generated from their connection to a some kind of database, in other words, their visual appearance is uniquely generated based on the content they represent.

D-series icons are far more sophisticated in their requirements than f-series because they must be generated through back-end data requirements. The level to which they might be attached to a database varies, but the ultimate dependency on such attachment and data demands is based upon the taxonomy, ontology, and visual manifest of the series. As with a simple icon series, each icon is composed of only a single signal-emitting, graphical device, or channel; f- and d-series icons may be similar in general appearance.
INTEGRATED ADAPTIVE ICON SERIES

A series of integrated adaptive intelligent icons differ from simpler forms because they possess multiple channels within their make-up. Usually, they appear as composite icons. Each component tied to a database is discretely informed; however, the components work together to yield a higher level of intelligence. These composite devices become extremely expressive once their language is understood. Generally, integrated adaptive icons rely upon pre-organized algorithms that channel data into discrete components, providing a type of “go/no go” to the components within the channels. In other words, integrated adaptive icons have clearly definable “jumps” in shapes, colors, and sub-forms. There is innumerable potential for shifts in patterns or colors within intelligent icons; therefore, their design must follow a logic that renders clearly distinguishable resultant imagery.

The icon hierarchy discussed here is based on divisions within symbols, series, adaptability, and integration. These divisions are valuable in design, planning and design deployment. HCSI are composed of five principle channels. Of these five, one contains a single type of signal, but the other four each contain two types of possible signals—therefore, there are what we refer to as nine layers composing an HCSI device. The second section of this paper will discuss these layers in greater detail. The HCSI presented in this paper are generally referred to as an intelligent icon series, and may specifically be called an integrated adaptive icon series.

ADAPTIVE DATA MAPPING

A deviation from the rule of clearly definable color distinction is desirable when benefits can be derived from an “analog” type flow of data. This is the case when information sets are not clearly pre-categorized (i.e. Inductively designed) toward the purpose of generating devices or components of devices. Instead, free-flowing data yields visuals that may be deductively understood.

This form of device generation, which we refer to as data mapping, permits myriad digital signals to take on analog characteristics within a series of polygons (usually an assemblage of squares). For this reason, we do not call these devices icons, as they are more allied to constrained symbol sets: they communicate through the construct that may be built “on-the-fly,” as opposed to being flowed into pre-designed iconographic shapes. One currently sees a very sophistication type of data mapping within stock-market tree maps.

Figure 17: Integrated adaptive intelligent icons are varying composite pictographic shapes generated from the data they represent. This example is taken from the HCSI series. Each contains five channels in its make-up: main shape, two interior shapes, a border, and a small ‘indicator’ shape. Four of the five channels permit two areas of signal distinction while the workflow channel (the HCSI icon’s colored dot) permits only a single-signal distinction. This breakdown accounts for the nine lines shown in association with the HCSI devices.

Figure 18: Data mapping provides useful visualization from the perspective of analysis and knowledge discovery. The signal display is permitted to have a wide range of frequencies within each channel. The super-assembly of the channels provides contextual insight into the nature of the data. These are not iconographic in the true sense.
DATA-MAPPED INTEGRATED ADAPTIVE ICON

It is possible to data map an integrated adaptive icon. In this case each channel is both shaped to an iconographic purpose and fed with (usually) real time data to generate an ever shifting visual device. This process would yield an extremely sophisticated icon. Users would be able to discern subtle shifts in data characteristics if they were pre-orientated towards analytical considerations. However, the jumps in color or form of the less sophisticated devices are probably more tailored to general practical workflow. In the image pictured it is clear that the channels of the data-mapped integrated adaptive icon remain discrete; therefore, their signals reference is equally discrete. It is the fluidity of color range that creates a subtle analog-like pattern. The best use of such intelligent icons would be a series of visual captures over pre-set time periods — a series of these could be “read” effectively.

GENERAL NOTES ON DEPLOYING MULTIPLE SETS

Visual designers must be cognizant of those factors that provide distinction and emphasis within a GUI. Typical design considerations of legibility, readability, hierarchy and emphasis apply when multiple classes or multiple series within a class of icons might be used within the same system. In general, the least number of the most effective icons is desirable. Within this number the clearest visual distinction between devices within a set and the clearest visual distinction between sets of devices would be the default goal. Within the hierarchy of classes, the greatest spread between class sets provides the highest level of distinction. This topic is discussed further on page 37.
Health Care Service Iconography
A Guide to HCSI’s Structural Taxonomy, Ontology, and Manifest

WILLIAM M. BEVINGTON, PIIM & DAVID FUSILIER, PIIM

Note: This paper delves directly into the HCSI logic and its application within an EMR GUI interface. It is designed to have a stand-alone function independent of the first section of this paper so that it may serve as a guide to the logic and composition of the Health Care Service Iconography.

OVERVIEW
With appropriate visualization healthcare providers can gain life-saving insight into patients’ histories and conditions. In order to provide healthcare professionals with a next-generation visual assessment of individual and practice-wide healthcare profiles, a logic may be developed that utilizes iconography as a proxy for the healthcare service event. In essence, a standardized series of symbols can be devised that summarizes the entire patient documentation set. Such “intelligent icons” will provide rapid orientation, assessment, and analysis while facilitating the effective transition from data to wisdom. These iconographic standards can then be integrated into an Electronic Medical Record (EMR) Graphic User Interface (GUI).

Ultimately, an EMR GUI utilizing HCSI as an organizing principle for content is based upon three hierarchical levels. These include: the electronic records themselves (content), the icons (compact representatives of content), and the arrangement of the icons prior to the drill down through icons to desired content (context). The benefits of such a system is that the representative icons, i.e., the HCSI, serve multiple roles simultaneously and unobtrusively. The icons permit access of content through their selection, and they provide analytical capabilities through their collective arrangement. They access specific content, provide content insight and actionable analysis through their arrangement, and serve as the control interface themselves in a GUI. The ramp-up to understand HCSI is designed to be intuitive, and the advantages to using these intelligent icons are numerous.

First, documents, or sets of documents, can be understood through highly compacted icons. This compactness has both cognitive value and a technical value. Second, the icons can than be arranged in multiple ways: such as in a storyline fashion, in tabular fashion, in chronological array, quantitatively, by specialization, by magnitude, etc.
This will allow healthcare providers to quickly organize, assimilate, and transform content into wisdom and informed action. Third, using such icons will ultimately allow actual, or representations of, electronic medical records to be far less dependent on multiple GUI controls that surround the actual informative content. Instead, the content itself becomes intuitively navigable. Ultimately, the GUI will be simpler in appearance, with more screen real-estate available for content (instead of navigational control), a significant advantage for smaller-screened field devices. Fourth, because the existing Current Procedural Terminology (CPT) code system is leveraged to generate icons within HCSI, healthcare providers and patients will begin to benefit greatly from the oftentimes disruptive, mandatory CPT code documentation process through visualized representation.

Currently, medical records are organized in portfolios or collections of healthcare activity. By deploying a method that abbreviates, compacts, and collects all of the healthcare services a portable system of icons can be displayed in any number of schemas (e.g. tabular form, depicted by hierarchy, over a map, etc.). Therefore, a healthcare provider is able to view the “big picture.”

Once a user is initiated to HCSI, it is quite easy to read the icons and develop a familiarization with the represented patient (or patient group). In the current iteration, the HCSI system carries up to nine layers of information within its compact structure. HCSI takes advantage of CPT coding, generating the majority of these information layers based on parallels in the CPT and HCSI taxonomies. Leveraging CPT codes within a health record will now provide rapid, visual, diagnostic value as well (providing an informatively advantageous benefit back to healthcare providers).

The following sections illustrate: an example of how a healthcare service icon is assembled, and, how a collection of icons may be rendered in a larger context to provide holistic and systematic management of patients.

**Figure 21:** Health Care Service Iconography (HCSI) can be referred to as an intelligent icon system. Each icon is uniquely built by reading available data respective to a particular healthcare provider service act. An icon within the system can be composed of up to nine layers of data. Irrespective of how many layers are available, the icons occupy the same amount of space. The icons have up to three functions: representing a collection of data about a service, showing that service in the context of other service, and serving as an access point to actual service records.

ARRANGING COMPOSITE HCSI

As every healthcare service is represented through consistent elements, these can now be constructed into highly informative arrangements. Drilling through these arrangements allows practitioners to navigate medical data rapidly; it can be understood how such arrangements of icons can allow providers to abstract increasing amounts of data from source material.

As an example, let’s say a 27-year-old recipient has three hundred medical encounters over their lifetime. Every service (inoculations, x-rays, and multiple procedures for a serious or critical condition) can be considered as an act of: Evaluation & Management, Data Collection, or Intervention. Each of these, in turn, are further specified by additional procedural subtypes, who performed them, where they were performed, and, of course, by outcomes and findings.

The data that supports an EMR GUI for an event record (containing any amount of task documentation) can generate a symbol that summarizes that specific event record and accesses all of the relevant task documentation. The icon can be, therefore, both a compact information device and the control button that can call up the record (or records) that it represents. This is why deploying HCSI can facilitate the creation of a next-generation EMR GUI: the content and the control are increasingly unified and the user can navigate the entire EMR system with far greater facility.

Every icon occupies the same space within a grid irrespective of the amount of data it “supports.” This means that the collective HCSI system can be arranged (and quickly rearranged): chronologically, categorically, by type of service, by service practitioner (similar to a traditional paper chart), by complexity, as a story line, over geospace, or through several other constructs. These constructs can then be modified or filtered through specific user collection preferences, such as a custom range of time, a specific set of HCSI devices, or through a personal workflow method.

HCSI provides a major developmental step for a holistic reading of electronic medical records through a dedicated or thin-client GUI. Further, HCSI can serve as the main content display within an existing system or evolve into a stand-alone GUI. As working interactive models deploying HCSI within a GUI toolset are generated, heuristics studies will reveal best practice respecting preferences (and how controls to rapidly alter HCSI arrangement may be designed).
STORYLINE

A typical arrangement within the HCSI system is referred to as a storyline: a simple, step-by-step sequence of healthcare services to a single patient. Subsequent sections of this document describe the nomenclature in greater detail, providing the language (taxonomy) for each of the layers and their meaning.

In the above diagram the sequence is read left to right: the leftmost icon represents the earliest service in the sequence. The HCSI system recognizes three types of healthcare services (all of which are present in this example): Evaluation/Management (Square), Data Collection (Diamond), and Intervention (Circle). Color is used to indicate the specificity, or department/specialty of service provider in question. Specificities shown include: Primary Care (Blue), Radiology (Dark Purple), Pathology (Tangerine), Orthopedics (Burgundy), and Surgery (Green).

FIGURE 2.4: Interpreting the storyline would yield the following insights: an uncomplex encounter with a primary physician at a clinic (rated as “2”) is followed by an extremely complex one (rated as “5”). The primary care physician requests an imaging service from a hospital’s radiology department, then again meets with the patient to discuss the results and a plan of action. The patient is referred to an orthopedist for a consultation that is also complex. The orthopedist then requests a lab from pathology, which comes back as “abnormal.” An experienced doctor (prior to drilling down to any actual records) already understands that a potential serious condition has been detected and is being analyzed (likely cancer, given that an orthopedist is ordering the blood test). The storyline ends with a surgical procedure sandwiched between a pre-op and a post-op encounters.
SPREADSHEET
In this arrangement the healthcare provider has chosen an HCSI layout that is similar to a traditional paper medical chart. HCSI support this, and additionally permits very specific, custom groupings that reflect user preferences. For example, a “New Results” tab could be generated which would pull only those services which are “unreviewed” by the user. Not only would such a grouping logic be possible, but it would be visually reinforced through the presence (or lack of) a black, red, or blinking green dot within the icon (indicating the documentation’s current level of user interaction). Intelligent icons arrangements such as these allow users to systematically review a patient’s medical history with a topical bias.

FIGURE 25: The spreadsheet arrangement closely mirrors that of traditional paper medical records. It allows a “tabbed” grouping of services based on traditional paper medical record grouping logics in addition to user-generated, customizable grouping logics. In the example above services are grouped into categories according to the two traditional grouping logics: similarity of type (the first four row groupings) or similarity of specificity (the last eight row groupings).
INTEGRATED CHRONOLOGY

An integrated chronological arrangement yields a number of advantages. First, they are provided with the "50,000 foot view." A rapid assessment of a patient’s history (within all, or a selected range of time) provides a concise portrait of the type of healthcare providers this patient has interacted with. Next, a density pattern of healthcare requirements is self-evident. This view works at a large number of scales and accommodates a great number of icons.

The image above is also typically indicative of another potential feature for HCSI: the display is shown as content (it falls within the information display, not the control area) within an overall GUI. Such a content display could be expanded to become the EMR GUI itself. Future iterations of HCSI compositions could integrate complete content control sets, permitting touch screen applications or in-the-field GUI devices (e.g. handhelds) to permit informed and facile navigation through healthcare information.

FIGURE 26: On the single-patient level, an integrated chronological arrangement utilizes the modular nature of HCSI to track healthcare service requirements over a period of time.

On the multi-patient level, HCSI is a useful business tool for medical practices, or, as a analytical tool for a wide array of healthcare oversight: prediction, resource allocation, cross-tracking. If the service event data set is expanded to include an entire practice, a physician or administrator may easily observe seasonal ebbs and flows not only of general service volume, but also the volume of specific service categories (such as flu vaccinations during the winter, or physical examinations before the start of school) and plan accordingly.

As the above example illustrates, HCSI arrangements allow the user to visually explore the “data exhaust” generated from healthcare services, transforming it into a valuable analytical tool.22
**GEOSPACE**

This arrangement graphs health services over geospace using the home address of patients. Health centers would find a feature such as this useful in explaining abnormal spikes and drops in particular types of services. In this fictional example, a user has requested that blood-work labs used to detect cancer with "abnormal" results be plotted over a map of New York City. A suspicious concentration of abnormal tests is shown in Greenpoint, a neighborhood of Brooklyn. Coincidentally, Greenpoint is also the site of one of the worst oil spills in United States history.

Although the typical physician would probably rarely use such a visualization tool in individual patient treatment, other practitioners working at a macro level would find the ability to use health records as a real-time research tool quite useful.

**Figures 27 and 28:** Geospace arrangements have figured importantly into the developmental history of epidemiology. This fictional example (upper image) uses patient addresses to plot instances of abnormal bloodwork indicating cancer over a map of Greenpoint, Brooklyn (the site of a large oil spill in 1950). In 1854 Dr. John Snow used a similar arrangement, tracking the source of a cholera outbreak in Soho, England to a single water pump (lower image).
In this arrangement, vital signs have been quantitatively graphed over time. Uniformly represented nodes have been replaced with simplified HCSI icons, appropriate to the scale at which they are reproduced. These HCSI nodes not only mark numerical measurements, but also indicate the point in the patient’s service history in which they were recorded. The icons also serve as links back to the specific service documentation which they represent. While graphing vitals over time is not something new to electronic medical record systems, the ability to simultaneously understand the context of each individual point of measurement through the use of intelligent iconography is both novel and a testament to the degree to which HCSI can be integrated into existing systems.

**Figures 29 and 30:** Unlike quantitative graphs in current EMR systems (bottom), HCSI adds an event context to medical measurements and serves as access points back to the measurement’s corresponding event documentation (top).
THE ANATOMY OF HCSI

The HCSI system is based on a taxonomy that reflects divisions of services within multiple aspects of healthcare provision. Collectively, these layers, in myriad possible combinations, are depicted through a uniform structure. The collective structure then represents a composite general service, or a very specific service, visually.

Each layer must be specific in its meaning. When the layers are combined the icons become ideograms. Each part of the icon depicts a specific characteristic relevant to the healthcare service and has a discrete meaning. The icons are similar to Chinese pictographs because each part has a meaning, yet they combine to form a new composite meaning.

The icons are called intelligent icons because they are adaptive: their specific visual appearance is generated by the same database that supports the greater EMR GUI.

In usage, every layer may not be depicted because data may not be available to support a particular layer. Also, users may choose (through preferences) to de-select or hide certain layers that are not relevant to their work. This section is a comprehensive list of the permutations within the system; it reflects the carefully designed taxonomy that underpins the visualization schema. It shows single, incremental builds of the exhaustive possible services between care giver and care recipient. This paper is intended as an overview, not as a guide to the technical generation of HCSI devices—the pages in this section provide proof of concept. The symbols are more readily learned through contextual usage then they are through component by component familiarization.

The layers are very briefly described at right in association with a representative icon. Each layer is then described in detail through this section of the document.

Layer 1: General Type of Service
Depiction through Shape

Layer 2: Specificity of Service Provider
Represented by Color

Layer 3: Subtype of Service
Represented by Primary Symbol

Layer 4: Abnormal or Alert
Represented by Color of Primary Symbol

Layer 5: Service Requested
Represented by Secondary Symbol

Layer 6: Specificity of Requester
Represented by Color of Secondary Symbol

Layer 7: Facility Where Service Performed
Represented by Border

Layer 8: Condition of Patient During Service
Represented by Color of Border

Layer 9: User Interaction with Records
Represented by Indicator

Figure 31: A sequential, layer-by-layer build-up of a single HCSI icon. HCSI icons are able to display a total of nine layers of information.
**Layer 1: Type [Shape]**
The first layer of information depicts the type of service, and is represented by the icon shape. Services are divided into three types: Evaluation/Management, Data Collection, and Intervention. The diamond shape of the example icon indicates that the service is of the “Data Collection” type.

**Layer 2: Specificity [Color of Shape]**
The second layer of information depicts the specificity of the service provider, and is indicated by color of shape. The orange color of the example icon indicates that the service is of the “Pathology” specificity.

**Layer 3: Subtype [Primary Symbol]**
The third layer of information depicts the subtype of service, and is represented by the icon primary symbol. The flask primary symbol of the example icon indicates that the service is of the “Lab” subtype.

**Layer 4: Alert/Abnormal [Color of Primary Symbol]**
The fourth layer of information depicts the alert/abnormality status of the service and is indicated by color of primary symbol. The white color of the primary symbol in this example indicates that the lab results were within normal healthy ranges.

**Layer 5 & Layer 6: Service Requested and Requester of Service [Secondary Symbol & Color of Secondary Symbol]**
The fifth and sixth layers of information depict if the service was requested and the specificity of the service requester, which is indicated by the presence of a secondary symbol and the color of the secondary symbol. The secondary symbol in this example indicates that the service was requested by the primary care physician.

**Layer 7: Facility [Type of Border]**
The seventh layer of information depicts the type of facility where the service is performed, and is represented by the border of the icon. The solid border of the example icon indicates that the facility in which the service was performed is a “Clinic.”

**Layer 8: Patient Condition [Color of Border]**
The eighth layer of information depicts patient condition at the time of service, and is represented by color of border. The black color of the border in the example icon indicates that the patient was in “Stable” condition during the service.

**Layer 9: User Interaction with Service Document [Tertiary Symbol]**
The ninth layer of information depicts user interaction with service document, and is represented by the tertiary symbol. The red dot tertiary symbol of the example icon indicates that the service has been “Read with Commentary” by the user.
**Layer 1: Type / Shape**

The first layer of information depicts the type of service, and is represented by the icon shape. Services are divided into three types: *Evaluation/Management*, *Data Collection*, and *Intervention*.

**Type: Evaluation & Management**

Service in which a doctor evaluates a patient’s current status and formulates a plan of action based on a doctor/patient interview and a review of the patient’s medical history. Composed of CPT codes found in the identically named section of the CPT Code Book.

**Through Shape:** Evaluation & Management (E/M)

**Type: Data Collection**

Service in which a doctor produces diagnostic imaging or measurements concerning the patient’s condition. Composed primarily of CPT codes not found in the “Radiology” and “Pathology” sections of the CPT Code Book.

**Through Shape:** Data Collection

**Type: Intervention**

Service in which a direct attempt is made to correct the patient’s condition. Composed primarily of CPT codes found in the “Surgery” and “Medicine” sections of the CPT Code Book.

**Through Shape:** Intervention
**Layer 2: Specificity / Color of Shape**
The second layer of information depicts the *specificity* of the service provider, and is indicated by *color of shape*. These color settings may be customized through preferences.

**Specificity: Primary Care Physician**
Service in which the attending or supervising physician has been designated by the patient the "Primary Care" physician

**Specificity: Internal Medicine, Family Medicine, and Pediatric Medicine**
Service in which the attending or supervising physician specializes in Internal, Family, or Pediatric Medicine

**Specificity: Radiology and Nuclear Medicine**
Service in which the attending or supervising physician both specializes either Radiology or Nuclear Medicine

**Specificity: Pathology**
Service in which the attending or supervising physician specializes in Pathology

**Specificity: Surgery & Pediatric Surgery**
Service in which the attending or supervising physician specializes in Surgery

**Specificity: Other**
Service in which the attending or supervising physician’s fit into no other categorical grouping (e.g. Dermatology, Psychiatry, Dentistry, etc.)
LAYERS OF SERVICE ICONOGRAPHY

**Layer 3: Subtype / Primary Symbol**

The third layer of information depicts the subtype of service, and is represented by the icon primary symbol.

**E/M Subtype: Level of Service**

The primary icons of E/M services denote CPT “coding levels.” These coding levels are an index of presenting problem severity, extent of history, extent of examination, complexity of medical decision making, and time (“1” representing the least extensive and “5” the most).

<table>
<thead>
<tr>
<th>Level</th>
<th>Through Primary Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E/M Layer&lt;br&gt;Level 1 Service</td>
</tr>
<tr>
<td>2</td>
<td>E/M Layer&lt;br&gt;Level 2 Service</td>
</tr>
<tr>
<td>3</td>
<td>For E/M&lt;br&gt;Level 3 Service</td>
</tr>
<tr>
<td>4</td>
<td>For E/M&lt;br&gt;Level 4 Service</td>
</tr>
<tr>
<td>5</td>
<td>For E/M&lt;br&gt;Level 5 Service</td>
</tr>
</tbody>
</table>

**Data Collection Subtype: Imaging**

A “Data Collection” service that utilizes electromagnetic radiation, magnetic fields, and sound waves to create diagnostic images and videos. Completely composed of CPT codes found in the “Radiology” section of the CPT Code Book.

**Data Collection Subtype: Labs**

A “Data Collection” service that analyzes fluids/tissues/samples from the patient. Completely composed of CPT codes found in the “Pathology” section of the CPT Code Book.
DATA COLLECTION SUBTYPE: TESTS
A "Data Collection" service that measures the performance of the patient against specific criteria in specific conditions. Composed of CPT codes found in the “Medicine” section of the CPT Code book.

INTERVENTION SUBTYPE: SURGERY
An “Intervention” service performed by a doctor involving cutting in which an attempt is made to directly correct a patient’s condition. Composed of a majority of the codes from the “Surgery” section of the CPT Code Book. Surgeries may occasionally be considered Data Collection (e.g. exploratory surgery).

INTERVENTION SUBTYPE: PROCEDURE
An “Intervention” service physically performed by the doctor that does not involving cutting in which an attempt is made to directly correct a patient’s condition. Procedures may sometimes be considered Data Collection. Composed of codes from both the “Surgery” and “Medicine” sections of the CPT Code Book.

INTERVENTION SUBTYPE: TREATMENT
An “Intervention” service that attempts to correct a patient's condition through the ingestion/application/exposure of chemicals, substances, or medication, through the filtering of blood, or through exposure to a corrective environment. Composed of codes from both the “Surgery” and “Medicine” sections of the CPT Code Book.

INTERVENTION SUBTYPE: PREVENTATIVE MEDICINE
Vaccination (Primary Symbol: Shield): An “Intervention” service which attempts aim to prevent the development of a condition(s) through vaccination and other methods.
**Layer 4: Abnormality/Alert/Color of Primary Symbol**
The fourth layer of information depicts the class (or the layer of ABMS specialization) of the service provider, and is indicated by color of primary symbol.

**Abnormality/Alert: Off**
Any service in which the service provider considers an alert unnecessary.

**Abnormality/Alert: On**
Any service in which the service provider considers an alert necessary. In the case of Lab Results, this alert indicates an abnormal reading. In the case of other services, this alert indicates that a physician has indicated the service to be of special attention.

**Layer 5: Service Requested/Secondary Symbol**
The fifth layer of information indicates that the service is requested service and is represented by the secondary symbol.

**Requested Service**
A service which has been conducted by one physician at the request of another. This is considered a consultation or referral if service is of the E/M type.

**Layer 6: Specificity of Requesting Physician/Color of Secondary Symbol**
The sixth layer of information depicts specificity of requesting physician, and is represented by color of the secondary symbol.

**Specificity of Requesting Physician**
Indicates the specificity of the requesting physician of a consult using the same color system defined in Layer 2.
**Layer 7: Facility / Border**

The seventh layer of information depicts the type of facility where the service is performed, and is represented by the border of the icon.

- **Facility: Clinic**
  Any service which is performed in a medical clinic.

- **Facility: Hospital**
  Any service which is performed in a hospital.

- **Facility: Field/Transport (and Default)**
  Any service which is performed outside a staffed facility.

- **Facility: Other Staffed Facility**
  Any service which is performed in a staffed facility that is not a clinic or hospital.

- **Facility: Home**
  Any service which is provided at the home of the patient.
**Layer 8: Patient Condition / Color of Border**

The eighth layer of information depicts *patient condition* at the time of service, and is represented by *color of border*.

**Patient Condition: Critical**
Denotes a service in which is performed on a patient who is in severe danger of death.

**Patient Condition: Stable**
Denotes a service in which is performed on a patient who is not in severe danger of death.

**Layer 9: User Interaction with Service Document / Tertiary Symbol**

The ninth layer of information depicts *user interaction with service document*, and is represented by the *tertiary symbol*.

**Interaction Status: Unread**
Denotes a service which the user has not yet reviewed through “drill down.”

**Interaction Status: Read**
Denotes a service which the user has reviewed through “drill down.”

**Interaction Status: Commentary**
Denotes a service in which additional commentary has been added by a healthcare provider (who is not the provider of the service on which the comment is written).

**Interaction Status: Requested Service Available for Review**
Denotes a service which was previously requested by the user, is now complete, and has not yet been reviewed through “drill down.”
NOTES ON DATA REQUIREMENTS SUPPORTING HCSI

The beauty of the HCSI system is that data, already contained in EMR GUIs can be readily deployed to build a better toolset. By using data that is already part of the patient documentation environment to generate intelligent icons, healthcare providers can realize terrific benefit.

Implementing a HCSI into an EMR GUI would have two major impacts on the workflow for healthcare providers (and other users) of such a system. Intelligent iconography will provide a far more rapid insight into the entire records collection through the representational devices (i.e., the icons), and the assembly of the icons will have an impact on the efficaciousness of the user’s workflow.

Certain information, formerly provided for accounting or protocol, may now assist in healthcare intelligence. Ideally, the HCSI system is read only; it has no impact on the available data, drawing only on that which is available to create a view of that data. However, the available data has a considerable impact on how the HCSI will be rendered. By turning groups of documents into generalized, representational symbols, users can ascertain the big picture and make better analytical decisions through contextual displays. Currently, the typical GUI is composed of controls on many levels and content displays that render the records in full scale. A central argument for implementing HCSI is that these two aspects (control and content) can become integrated, whereby intelligent icons are also a gateway into the records.

It is to be noticed that intelligent iconography may be generated at multiple levels, from minimal to maximal quantities of data; therefore, they can be “evolved” into a program. In order to generate a “complete” HCSI device, that is, to build all nine layers, the data must be available to do so. The term build is used throughout this document to describe the process. The following page illustrates how the composition of the three HCSI intelligent icon types build upon differing levels of available data.

Figure 33: Maximum number of desired data values to build out most complex intelligent icon within the HCSI system:

(Note: The three examples given above are appropriately jarring in their visual display as they all portray services performed on a patient in critical condition.)
CPT CODES:
Type (Layer 1),
Subtype (Layer 3),
E/M Only: Requested Service (Layer 5)
E/M Only: Facility (Layer 7)

PHYSICIAN ABMS CERTIFICATION
Specificity (Layer 2)
Data Collection & Intervention: Requested Service (Layer 5)
Specificity of Requester (Layer 6)

CPT LEVEL II CODES
Data Collection Only: Abnormal/Alert (Layer 4)

USER ENTRY
E/M & Intervention: Abnormal/Alert (Layer 4)
E/M & Intervention: Facility (Layer 7)
Patient Condition (Layer 8)

USER INTERACTION
E/M & Intervention: Abnormal/Alert (Layer 4)
Patient Condition (Layer 8)
Interaction Status (Layer 9)
**HCSI WITHIN THE WORKFLOW MATRIX**

The diagrams on this page (which are enlarged and individually discussed on the following pages) use HCSI matrices to illustrate the interrelationship between accumulated event-spanning and event-specific data relative to a selected service (encounter, labs, surgeries, etc.) and the composite patient profiles.

The first three matrices illustrate the cumulative effect of subsequent services on the data collection from the perspective of the most recent encounter. As each encounter is performed (referring to the pink highlighted areas within the matrices) relevant event-spanning tasks (within the blue section) utilize data from past events, while relevant event-specific tasks (within the tan section) do not. The factor of importance is that the EMR GUI user is able to access, update, and review event-spanning tasks within the context of an encounter without the need to navigate off their current view; the illustrated matrix underscores this.

The fourth matrix illustrates a scenario where a user reviews a past service. In this case the user will not be supplied with any data recorded after that selection. In other words, the user will not see data from “future” services. The benefit of not incorporating future task data into past service records is that it preserves contemporaneous “attributability” and “context of observations.” For more useful explanatory detail in these areas see A. L. Rector, W. A. Nolan, and S. Kay’s “Foundations for an Electronic Medical Record.”

The final matrix includes a patient profile row, which, in this example, is selected. The patient profile is a record view which is always up-to-date with the entirety of a patient’s event-spanning documentation. In other words, every non-event-specific instance of documentation is included in the patient profile. This view is useful for patient record review outside of an actual patient service, allowing a user to instantly access specific task documentation without having to hunt through previous service documentation. Patient profiles are typically a strength of current EMR GUI systems (see page 35).
Figure 34: (Compare to the matrices on pages 3, 6, and 9) This series of integrated matrices conceptually illustrate how the implementation of HCSI improves the navigation for an EMR GUI.

First, there is the efficiency gained from not isolating event-based from task-based protocols (neither is subservient to the other).

The critical navigatable bridge is the use of intelligent icons. They are shown in a simplified form in the left-hand event column (Encounter 1, Encounter 2, Radiology 1, etc.).

All the matrices shown to the right present examples of event sequences with the most recent encounter highlighted in red. To clarify, the first example shows three encounters; the third, i.e. the most recent, is highlighted. One can see that for each event-spanning task relevant to this encounter (blue highlights), current event-spanning data is included as well as like data from previous encounters (all pink highlights within the blue section). In addition for each relevant event-specific task (brown), current event-specific data for the event is portrayed (pink highlights within the tan section). Note that solid dots represent past data points and open circles represent current data.

The reason contextual data of the kind described and portrayed in these matrices is made possible through the use of HCSI is because each of the data points is itself represented by an HCSI icon. In essence, the user does not need to navigate back to the column or row reference menus. Instead the selection of any data point (an HCSI intelligent icon) will launch its own full contextual matrix. (See also wireframe diagrams and commentary on Pages 37 – 41)
**Figure 35:** The matrix shown to the right presents an event sequence with a past encounter highlighted in red. For each event-spanning task (blue highlights) within the selected encounter, like data from non-selected previous encounters (pink highlights) is shown. In addition, for each relevant event-specific task (brown highlights) the concurrent event-specific data is portrayed (the two pink highlights). Note that only solid dots are portrayed in this example, as there is no current data (open circles). Event-spanning data from tasks occurring after the selected previous encounter are not highlighted because this is a historical view (at the time of the encounter, this data did not yet exist). Browsing previous encounter documentation is useful for physicians when familiarizing themselves with the history of a new patient and also for legal documentation purposes.

The principle strength of current EMR GUIs is that they permit healthcare professionals to have up-to-date and categorical information respecting a patient, in other words, EMR GUIs are patient profile toolsets. Even this functionality can be improved with intelligent iconography by portraying all event-spanning task data available over the lifetime of the patient.

In the matrix shown at right, patient profile is selected. This selection allows the user to both record and review data under every event-spanning task outside of any particular service event.

From the four matrices shown on this and the previous page, a logic for how the integrated selection of encounters, tasks, composite profiles combining event-specific and event-spanning data can be discerned.
HCSI WITHIN AN EMR GUI INTERFACE

As stated, this white paper focuses on the design of HCSI, a specialized group of intelligent icons for the medical profession, toward the purpose of deployment within an EMR GUI toolset. The underlying argument is that intelligent iconography, specifically designed for any discipline-based GUI, can increase efficiency and cognitive advantages. Intelligent iconographic sets do require a "ramp-up" of familiarization. This paper concludes with a general recommendation (shown through highlighted interface examples) of how HCSI could function within a proprietary EMR GUI environment. The logic of what is shown may be extrapolated to apply across other disciplines, or even other related professions (health insurance, pharmaceuticals, Medicare and Medicaid, pathology tracking, etc.). The example above and those that follow show a single screen-capture exhibiting how HCSI in a prototypical deployment environment will function.

FIGURE 36: The Payoff: This diagram contains the layout for a proposed EMR GUI utilizing HCSI. The promise of an integrated event-based and task-based system is evidenced through the HCSI shown in left column.

The highlighted column depicts nine events represented by corresponding HCSI in the primary navigation field. The healthcare provider can readily see a combination of surgeries, diagnostic tests, and patient encounters prior to drill down.

This example shows icons for "All Services" arranged in simple chronological order. However, they may be filtered using the orange tab controls below into the other grouping logics similar to those found in traditional medical charts and those used in the spreadsheet diagram on page 16. In addition, the bottom grey controls create and manage custom filter for myriad arrangement possibilities along three principle dimensions: the components of the intelligent icons (type, subtype, specificity, etc.), aspects of the event data, or ranges within aspects.
NOTES ON THE USE OF COMPETING ICON TYPES

At least five considerations are worthy of evaluation:

- The types of classes used (See pages 10 and 11.)
- The total number of series used
- The general visual distinction between the types of classes and series used.
- The number of devices within each series
- The specific visual distinction between devices within each series

In addition to HCSI, a supplementary integrated adaptive icon series (HCX) is used to represent the composite content of the patient profile. HCX is not the topic of this paper but is included here to provide a contextual GUI buildout.

**Figure 37:** The GUI shown deploys five series of icons. This was felt to be the minimal possible to provide full functional facility. Two types are integrated adaptive icons: HCSI and HCX. HCX is a distinctive supplementary set which allows users to draw conclusions about composite patient profile data. As stated in Figure 35, the patient profile allows the user to access all event-spanning tasks outside of any service event. HCX is the integrated adaptive icon which permits this function. Although the details are not discussed in the paper, the visual composite, as with HCSI, provides a shorthand understanding of the content that is displayed after drill-down.

In addition to the above two integrated adaptive icon series sets, three additional adaptive f-series sets are used to facilitate workflow and not represent content. They control actions at the system, module, and object levels. Importantly, the integrated adaptive icons do not compete with other low-level classes at the visual and data content levels: this results a rich, but focused visual vocabulary.
TASK CONTROL AND TEMPLATE MANAGEMENT

Intelligent icons in the form of HCSI provide two critical benefits upon selection and initial drill down. First, due to their compositional nature they package of healthcare tasks. Therefore, selecting any HCSI device populates a list of explorable task modules of explicit and targeted interest which are clearly divided into event-specific and event-spanning protocols. Second, by default, they do not generate a list which includes irrelevant task modules. This benefit is a significant saver of both user time and GUI real estate.

Another area of particular utility to healthcare practitioners falls under the aspect of template design. A general default template list based on the HCSI taxonomy can be easily customized to provide both a highly focused horizontality and extensive verticality within the selected service event (see content matrices for reference on pages 34 and 35). Ultimately, GUI designers could serve users by designing templates linked to CPT codes, thus permitting more rapid and consistent medical documentation.

FIGURE 38: As the HCSI render visual insight into underlying content, the secondary control panel provides only those tasks relevant to the service event selected. Users do not have to scroll through lists of irrelevant tasks, nor close and open drop down menus to navigate desired activities. The three sections within the secondary control panel include the event details, which provide textual elaboration upon event selection; the previously described, task list, further divided into event-spanning and event-specific lists; and finally, template management controls, which allow the users to add and remove tasks, as well as to save and load templates.
CONTROL AND CONTENT INTEROPERABILITY

In the ultimate EMR GUI, HCSI devices stand strategically and effectively at the crossroads of four workflow vectors: control, content, task-based logic, and event-based logic. It is the fluidity and cognitive adaptability of intelligent iconography that permits their multi-faceted nature. Let us succinctly tie each of the four vectors, which now have been covered at different levels of explanatory detail throughout this paper, to their actual deployment in the GUI.

I. CONTROL AND HCSI

HCSI devices serve as selective controls. At the simplest level, they can be understood as one dimensional buttons, i.e. “push this and a list opens.” Rising from this level, they have shapes, internal pictographs and color coding that allows users to have a preexistent knowledge of the nature of the services and service data that they represent. Caregivers deeply familiar with the patient would develop an ever increasing preexistent knowledge of the tasks yet to

FIGURES 39 and 40: Content manifestation can be generated over four principle information design schemas: pictoral, quantitative, relational, and symbolic. In the example above, the HCSI, are displayed upon a quantitative basemap, acting as both control devices and content devices. HCSI is deployable through whatever presents the most useful schema.
be revealed in the secondary control. Concluding, they are best understood as collapsed folders containing a specific list of only those healthcare tasks relevant to the selected event. HCSI controls beautifully fulfill the Goldilocks principle— they reveal a list of tasks ideally suited to the healthcare providers needs relative to the service. Consider the heuristical benefit for the users when, despite any level of preexistent orientation to the selected service they are presented the exact items that they need. No searching through large module lists and dropdown menus, and single-click access to such a list.

II. CONTENT MANIFESTATION AND HCSI
The HCSI “control buttons” can be distributed over contextual backgrounds providing a superorientation to the ultimate content that they shall reveal. In short, they can be seen placed within lists, tables, graphs, quantitative displays, and maps. More specifically, we refer to these arrangements as content manifestation or information design. There are four principle areas where icons, and specifically intelligent icons, render higher levels of contextual knowledge: within pictorials, within quantities (shown in the examples on the previous pages), within relationals, within other symbol sets. It is noteworthy that within any of these contexts they simultaneously function as buttons. Therefore, when insight is ascertained through their contextual placement, they can immediately serve as doorways to specific data.

III & IV. TEMPORAL VECTORS AND HCSI
HCSI supports two logics: Singly, they represent a group of tasks performed during a single healthcare event (event-based navigation); Collectively, they represent a single type of task performed over a sequence of healthcare events (task-based navigation).

In this paper, we have generally used the terms event-specific documentation and event-spanning documentation. Ostensibly, another way of looking at these documentation types is as task-spanning documentation and task-specific documentation.

The beauty of HCSI is that it serves as a unifying bridge between both healthcare navigational logics: by event and by task. The two side-by-side navigational columns (shown in the examples on the previous pages) reveal this. The first column allows for event-based navigation; the second column allows for task-based navigation. This is in direct contrast to current EMRs which navigation with an either/or protocol. When accessing one protocol, the users are blind to the corresponding data of the other. Essentially, users must carry the comparison in their mind.

CONCLUSION
Current EMRs are built upon simple, yet ineffectual, underlying taxonomies. Consequently, they cannot effectively support healthcare professionals’ complex workflow needs without requiring a multitude of taxonomical exceptions. These work-arounds result in data redundancies caused by excessive structural compartmentalization and navigational inefficiencies. Such a foundation may be reffered to as a complicating simplification.

Health Care Service Iconography is a discipline-centric set of intelligent icons. They represent a simplifying complication. When integrated into an electronic medical records graphical users interface they permit such toolsets to become more beneficially simple in usage due to their complex underlying taxonomy.

HCSI implements an underlying event-based logic that structurally supports and seamlessly integrates with task-based modules. HCSI eliminates data redundancies, structural compartmentalization, and navigational inefficiencies. Deploying HCSI results in a cleanly logical wireframe architecture workflow and seamless navigational capability.
Biographies

William M. Bevington currently serves as Associate Professor of Information Mapping in the School of Art, Media, and Technology at Parsons The New School for Design, The New School, New York. He formerly served as the Executive Director for Parsons Institute of Information Mapping, Chairman of the Communication Design department at Parsons School of Design, and various professorial and instructional roles at his Alma Mater, The Cooper Union for the Advancement of Science and Art. He is an Information Designer and Information Theorist specializing in creating tools for the rapid assessment of complex data. His first significant project was the Blackout Procedures Manual for Con Edison in 1983, and the last was a major Geospatial Media Mash-up Tool under U.S. government contract entitled the Geospace and Media Tool (GMT). Mr. Bevington has developed toolsets for transit systems applications, stock trading applications, and health management tools as a principle designer at Spire Integrated Design, New York. He has lectured worldwide, illustrated Graphic Designers Production Handbook, co-authored Working with Graphic Designers and Designing with Type with Jim Craig. He is also the author of Typography: The Principles, A Basic Guide to Using Type published by The Cooper Union.

David Fusilier currently serves as an information designer at Parsons Institute of Information Mapping and as a graphic and typographic designer at the Brooklyn-based Darden Studio. He is a recent graduate of Parsons The New School for Design, The New School, earning his BFA from the Communication Design and Technology Department. Formerly, he pursued a premedical curriculum at Louisiana State University, complimented by jobs working as both a medical records clerk at the Baton Rouge Clinic and volunteer in the endoscopy department of Our Lady of the Lake Hospital.

Notes

1 "...most physicians feel that the right type of EMR is not available yet. To understand what I mean by this, one must have an understanding of how a medical practice works and what an EMR system is meant to replace—a paper chart... For the physician, the paper chart is a very efficient method for seeing patients in a clinic—one that has been around for a hundred years.” Kishore Tirirpeni, MD, “The Problem with EMRs: Why EMRs Fail, A Practical and Pragmatic Approach (2006); In a general sense, varying forms of medical documentation stretch back for hundreds, if not thousands of years. Ethel E. Thompson, “Doctors, Doctrines, and Drugs in Ancient Times,” (New York: Library Research Section, Eaton Laboratories, 1962); “The importance of health medical records in health care delivery has been recognised for a long time. Its relevance to patient care and health administration was documented by Florence Nightingale in 1873 book entitled Notes on a Hospital.” Terry J. Hannan, “Electronic medical records,” Health Informatics: An Overview (1996), 1.

2 However, our concern deals with the emergence of formalities and consistencies within the practice, in particular the Problem-Oriented Medical Record (POMR) as identified by Lawrence Weed, MD In an interview with Lee Jacobs, MD, Dr. Weed references his publication, stating, “As I wrote in 1969, "The beginning clinical clerk, the new intern, and the practicing physician are confronted with an apparent contradiction. Each is asked, as a “whole” physician, to accept the obligations of meeting many problems simultaneously and yet to give to each the single-minded attention that is fundamental to developing and mobilizing his or her enthusiasm and skill, for these two virtues do not arise except where an organized concentration upon a particular subject is possible." The multiplicity of problems the physician must deal with every day constitutes a principal distinguishing feature between a physician’s activities and those of many other scientists.” Lee Jacobs, “Interview with Lawrence Weed, MD: The Father of the Problem-Oriented Medical Record Looks Ahead,” http://xnet.kp.org/permanentejournal/sum09/Lawrence_Weed.html.

3 "Weed was instrumental in focusing the attention of the medical profession on the medical record and in establishing the idea of ‘problems’ and the ‘problem list’ as central features of many medical record systems. A major goal of Weeds’ work was to facilitate computerization of medical records, and many computer-based systems claim
to implement all or part of Weeds’ system. Nevertheless, Weeds’ Problem Oriented Medical Record has not been widely accepted in the form in which it was originally conceived.” A. L. Rector, W. A. Nolan, and S. Kay, “Foundations for an Electronic Medical Record,” (Manchester: Medical Informatics Group, Department of Computer Science, University of Manchester, 1991), http://www.opengalen.org/download/FoundationsofEMR.pdf


6 Paulraj Ponniah, Database Design and Development: An Essential Guide for IT Professionals (John Wiley and Sons, 2003) In a textbook chapter titled “Basic Database Concepts,” the term duplicate or duplicate occurs 19 times, In every instance the notion of duplicated data is expressed in the pejorative. From this simple analysis, it can be clearly understood that duplication is an undesirable condition in the design of database structure.

7 Colene M. Byrne, et al, “The Value From Investments In Health Information Technology at the U.S. Department of Veterans Affairs,” (The People-to-People Health Foundation, 2010); Hannan, “Electronic medical records,” 9. This source contains a useful bulleted list of “Existing EMR models and confirmed benefits of EMRs.”

8 “A combination of technology that was difficult to use and providers resistant to changing their ways has kept the digital office from reaching widespread use. Early EMR systems offered little in the way of compatibility with other systems, often relying on proprietary software that required frequent upgrades and revisions. It has been said that 50% of EMR installations have failed, and experts attribute those failures to a lack of planning, trainings, and ongoing support through the transition and afterward. Vendors were focused on sales, and physicians had unrealistic expectations about the ease of transition. The workflow changes that were needed in order for the system to work were never implemented, leading to failure and lost revenue.” Edward B. Ermini, MD, “Creating a National Health Information Network: The Importance of Individual Provider Participation” North Carolina Medical Journal 66: 3 (May/June 2005), 1.

9 A strongly worded comment by Colonel Brad Waddell taken from an online town hall meeting held by the Department of Defense to discuss AHLTA: “…I remain completely disappointed. AHLTA was designed for administrators—not clinicians—it’s slow, inefficient, unreliable and in every respect, [and] an inferior product compared to other…available EMRs.” Maggie Mahar, “AHLTA Continues to Disappoint” (August 04, 2008).

10 “Our goal, at that time, was to extract all of the information from every available record and place them all into a single growing template. This would eliminate duplication and bring all the intelligence into a single record. We had a problem with this; at that time the protocols between every piece of equipment supplying data were in no way compatible.” Interview with Siu L. Chong, Interface designer who worked HCVN interface from 1992–1993.

11 See note 7.


strongly worded letter, Daniel Palestrant, MD, cites CPT coding as impeding workflow without benefitting patients. During informal physicians interviews conducted by this paper's authors during the development of HCSI, clinicians expressed similar sentiments in regards to the tedious CPT coding process.

22 "Data, Data Everywhere," The Economist (February 27, 2010), 3–18.

23 See note 21.

24 See note 3.


(All cited URLs in this paper were accessed for content at the time of publication)

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