Next-Era Infusion Management Systems: Inherently Intelligent from the Start

George Gray

Healthcare runs on information—a ceaseless stream of data, reports, and images flowing through an ever-growing proliferation of interconnected devices, systems, and networks. This “information ecosystem” is as vital to the health of a healthcare organization as it is to the health of the patients the organization serves. This is what defines the next era in healthcare: the ability to take full advantage of the information ecosystem.

For most of us, this is already part of our everyday lives. Perhaps the best-known example is the progression from landline to mobile phones and from flip phones to smart and intelligent phones. For a device to be intelligent, it has to be able to turn data into knowledge, gathering up-to-the-minute information and making it available to users—whether it’s individuals working on their own or multiple users working in collaboration.

Computerization and wireless connectivity transformed the flip phone into a personal computer and, from that day forward, the way humans interact with the world. All of a sudden, we had devices that allowed us to peer into the information ecosystem anytime, anywhere, essentially dissolving the limitations of time and space. With a flip phone you could talk to another person or send a short text. With today’s smartphones, you can search for information, collaborate with others, get just-in-time updates, and review a seemingly endless amount of data from a seemingly endless variety of applications (apps). And you can make a phone call.

Accomplishing this transformation required fundamental changes in thinking, software, and system architectures. Early flip phone developers chose to use analog signals (electric impulses of varying amplitude) to transmit information, which limited the transmission speed to allow them to create smaller devices. But analog phones were soon eclipsed by those based on a binary format (zero or one) using two distinct amplitudes. Similarly, early smartphones from Japan transmitted data using cHTML, a language that restricted traditional HTML (Hypertext Markup Language) to increase data transmission speed. But cHTML phones were eclipsed by still smarter phones, with 3G followed by 4G Internet speeds, requiring more advanced architectures.

Today, essential elements for mobile devices and systems include high-speed transmission; large, four-color, easy-to-see touchscreens; simple, intuitive menus; and architectures fundamentally different from those of early designs. As a result, it seems that everyone is carrying around one of these personal computers in their pocket.

The same types of transformations are happening in healthcare to provide organizations, agencies, and individuals with the technologies they need to fundamentally improve care. Many providers see the improvements in care shown in Figure 1 as

About the Author

George Gray, BS, MS, is chief technology officer and vice president of research and development for Ivenix in North Andover, MA. Email: ggray@ivenix.com
being linked to their vendors’ ability to provide the information needed to make good and timely clinical decisions. This requires new ways of thinking to create systems and devices that are specifically designed for the information ecosystem.

**Transformational Healthcare**

If you were building a brand new hospital, you would never start with 20-year-old plans. You’d want to start fresh, because once the plans are drawn and the foundation is poured, fundamental changes are no longer possible. The core architecture has to meet the demands from the start.

Now consider patient care. Some of the most critical, high-risk, high-cost therapies are administered via intravenous (IV) infusions. IV pumps are used for almost every patient to deliver fluids ranging from normal saline to complex chemotherapy regimens. Clinical use of smart pumps began at Massachusetts General Hospital in 1996. Since that time, smart pumps have accomplished much with regard to averted errors, improved administration, and interoperability and have become a widespread standard of care. But major problems remain. The ECRI Institute listed infusion errors as its number one health technology hazard for 2017, and the Institute of Medicine estimated that infusion-related adverse drug events add more than $2 billion to annual healthcare costs in the United States (in 2006 dollars). ECRI suggested that improved interoperability would help address 75% of the errors in its database. However, this would still leave 25% of potential medication errors unaddressed. Much remains to be done.

A general lack of innovation inherently limits current systems. The vast majority of today’s IV smart pumps are running on architectures that are 20 years or older. Dose-error reduction software (DERs) was added to help avert pump programming errors. “Dumb” IV infusion devices were made “smart” by computerizing the pumps and later improved by retrofitting wireless capabilities and supporting bidirectional communication with the electronic health record (EHR). But the basic architecture has remained the same. Little has been done at the point of care to improve the user experience and reduce medication errors considerably. The healthcare industry remains plagued by tens of thousands of adverse drug events, hundreds of deaths, and the enormous costs associated with managing a fleet of pumps that is not built to take maximum advantage of today’s information ecosystem. A new era requires an equally new approach.

**Requirements for Meeting Current Needs**

Transformational software and system architectures are the foundation for achieving major innovation in IV infusion management (Figure 2). Languages and applications based on optimal architecture will provide the foundation required for new approaches to interoperability. Data can become knowledge at the bedside and help administrators design roadmaps for improving care.

In our increasingly complex world, multidisciplinary collaboration has become a necessity. Systems and devices that support collaboration and clinicians’ ability to care for patients will continue to play an increasingly important role.
Consider the DERS drug library. With legacy systems, reaching consensus on the thousands of individual entries is an enormously time-consuming process. Members of the multidisciplinary drug library team may be separated by hundreds of miles and have widely differing schedules.

Next-era infusion systems could greatly simplify and speed the process by allowing reviewers to collaborate online, whenever and wherever they choose. Individual reviewers could use information technology (IT), which is built into the infusion system itself, to access an assigned drug entry, suggest changes, post remarks, see each other’s work, and confirm the final, agreed-upon entry. A system dashboard could allow the pharmacist to view the history and status of all drugs and easily include finalized entries in the drug library as soon as they have been approved. This more advanced collaboration also would facilitate more rapid, efficient, and continuous drug library optimization.

Patient care and staff collaboration are no longer bound by the four walls of a single hospital. An infusion system that only works in that environment is, at best, a legacy of past practices. To take full advantage of today’s information ecosystem requires an infusion management system that has been designed from the ground up, with IT built in and the ability to operate and communicate from anywhere. A few fundamental principles will define success.

**Fundamental Principles**

**Simplicity**

A primary design consideration is to make the technology easy to learn and use. People who could never program a VCR now navigate their iPhones freely. The large, four-color touchscreen and underlying architecture make the phone easy to see, understand, and use. Navigating the menu, opening apps, and, of course, making calls have become almost intuitive. Medical devices need to empower clinicians in the same way, making the right thing to do the easy thing to do, by making critical information simple to access, view, and understand. Simplicity also means eliminating information and tasks that are not useful. The goal is to get technology out of the way and allow clinicians to focus on caring for patients.

**Clinician-Ready Information**

The second fundamental principle for success is the ability to deliver clinician-ready information in the right way at the right time, when, where, and how it is needed. Unlike an EHR, bedside devices can capture distinct events in real time and combine that information with other recorded patient information to help inform clinicians. Too much information will introduce confusion, while overly invasive and frequent notifications likely will be ignored. Instead, information needs to be relevant, timely, and actionable.

For an IV infusion management system, that means providing information that is associated with the therapies being administered at the precise time and place that it is needed. Achieving success in providing clinician-ready information will require the following.

**Seamless connectivity.** Data transmission and stakeholder interactions have to be consistent and reliable.
**Interoperability.** Prepopulating the pump with the ordered infusion parameters transmitted from the EHR continues to gain adoption. For this to occur, reliable interoperability between the smart pump and EHR, using barcoded medication administration (BCMA) or an alternate approach, is mandatory. But we shouldn’t stop there. Manual programming still is required for actions such as dose changes (i.e., titrations), loading doses, and bolus doses. These types of programming occur more frequently with high-risk medications, making automation around these areas critical to improving patient safety.

**Mobility.** Both clinicians and patients are highly mobile. Most clinicians do not spend the majority of their day with one patient, and they may need to make decisions while not at the bedside. As a result, information has to be easily accessible and available anywhere and anytime it is needed. Access to ongoing infusion information through mobile dashboards enables this level of mobile decision making. Until now, a good deal of relevant clinical information typically has resided only at the central nursing station. Being able to view that information on the pump itself would further strengthen the clinical decision-making process.

**Cybersecurity.** Infusion systems must be connected to support the growing needs of healthcare facilities. However, as connected devices, infusion systems must adhere to the cybersecurity standards of the healthcare enterprise, without exception. If connectivity is not supported by a fundamental architecture that is designed to mitigate cybersecurity threats, then it can be a vulnerability in itself. Healthcare organizations must be knowledgeable of potential cybersecurity threats and fluent in the basic principles for evaluating how medical device connectivity can affect enterprise security. For example, requiring that each vendor provide a Manufacturer Disclosure Statement for Medical Device Security (MDS)® form is important, as it can help staff gain a consistent understanding of each system’s potential vulnerabilities and make valid comparisons among vendors’ different offerings. Additional cybersecurity resources are provided in the sidebar.

**Future-ready platform.** An inherently intelligent device also must be able to adapt to healthcare’s ever-changing demands. This requires a malleable, extensible architecture that is able to fit wherever the future leads, thereby enabling a world where:

- Precision medicine uses all available information about a patient to produce the most informed care plan possible.
- Patient care extends unencumbered by the four walls of the hospital.
- Remote care uses monitoring and devices that can move seamlessly from the hospital to lower-acuity settings and into the home.
- Devices continue to operate and communicate with centralized care systems regardless of their location, and a seamless flow of data and information helps users guide critical decisions (clinical, operational, and financial) to continuously improve outcomes while reducing costs.

**Conclusion**

The future of patient care will be transformed by a focus on the continued creation of knowledge. To meet the demands of the future, organizations must carefully consider the presented features and how they can be adapted to the specific needs of their patient populations. This will require a proactive, integrative approach that includes network security, mobile access, and intelligent technology, all of which are critical to improving the overall quality of care while ensuring patient safety and privacy.
information ecosystem, infusion devices need to be built with “IT inside,” interoperate with other devices and systems both within and outside of the facility, and provide users with timely and accurate information to support effective clinical decisions. These capabilities are critical to helping hospitals achieve the following goals.

**Reducing medication errors.** 1) Simplify the entire user experience and eliminate unnecessary tasks. 2) Integrate with systems and data sources, such as BCMA, that can eliminate costly transcription errors. 3) Reduce dosing errors by continuing to improve the use and visualization of clinical knowledge.

**Enabling timely decisions.** 1) Provide solutions that support the mobile clinician’s need to make timely decisions. 2) Integrate seamlessly with the EHR to ensure that real-time infusion data always are part of the patient record. 3) Provide ways to bring information to the bedside that supports the infusion delivery process.

**Improving effectiveness of clinicians.** 1) Eliminate non–value-added user requirements. 2) Streamline the clinical workflow. 3) Reduce alarm fatigue. 4) Use data analytics to evaluate and continuously improve the care process.

**Recapturing lost revenues.** Automate the tracking of administered infusions to ensure compliance with the patient record and associated charges.

Regardless of the changes the future may bring, IV infusions will undoubtedly continue to provide ubiquitous, essential, and life-saving therapies. Optimizing IV therapies and improving treatment while decreasing costs requires IV infusion management systems that are built from the ground up for information and infusion, protected from a cybersecurity standpoint, and ready for 21st century healthcare.

**References**