Challenges for Social Infrastructure R&D in India

N. Vinoth Kumar

OVERVIEW: India is a large nation with a growing level of infrastructure investment. Key challenges for global businesses include India's expansiveness and the economic, cultural, geographical, environmental, and political diversity this brings. One question that must be asked when market opportunities arise is whether a product, solution, or service can be adapted to the Indian market with only minor changes, or whether significant redesign is needed. Given that India's diverse market includes a broad spectrum of local and global competitors, each with their own competitive advantages, redesign of the product, solution, or service may be needed just to cope with the market's diversity. This redesign must address three key issues: (1) whether mass customization can be used to scale the features and affordability, (2) whether the product can stand up to harsh operating environments, and (3) whether the interface is suitable for the diversity of end-users. Given their local knowledge and implicit understanding of India's diversity, this redesign for India is, in many cases, best undertaken by local researchers.

INTRODUCTION

SOCIAL infrastructure investment in India is doubling every five years, with a budget of $US1 trillion for the Twelfth Five Year Plan (2012–2017)(1). This investment can be divided into a variety of categories, including by sector (including power, transportation, and water), state (Gujarat, Tamil Nadu, and so on) and type of community (including rural, semi-urban, and urban). While some projects are entirely government funded, others are public-private partnerships (PPPs). The government-funded projects tend to focus on the bottom of the pyramid, particularly people living in rural areas. PPPs, meanwhile, are focused more on the middle class and affluent, especially in the area of urban infrastructure.

The key challenge therefore is to adapt technologies to suit the diversity of India, which extends from affordability at one extreme to cutting-edge at the other. Global infrastructure companies are localizing both manufacturing and research and development in order to remain competitive. However, cost savings achieved through local manufacturing and adaptations are insufficient for business groups that aim to supply the entire Indian infrastructure market. Redesign is also essential to create platforms that address the needs of a diverse, changing, and large society.

This article considers five stages of evolution in infrastructure technology (see Fig. 1). These are: nonexistent infrastructure, unstable infrastructure, unreliable infrastructure, high-quality infrastructure, and fail-proof infrastructure. Using power infrastructure as an example, the dotted line in Fig. 1 represents the target root mean square voltage in a distribution line. The first stage of evolution corresponds to the case when a region lacks any power infrastructure, the second stage to the power supply being unstable both in quality and availability, the third stage to greater availability but with quality still poor, the fourth stage to high-quality power that remains vulnerable to natural disasters and other special circumstances, and the fifth stage to a system that guarantees both quality and availability. Note that, while the fifth stage appears ideal, the system may require a level of redundancy that makes it inefficient and less valuable in some cases.

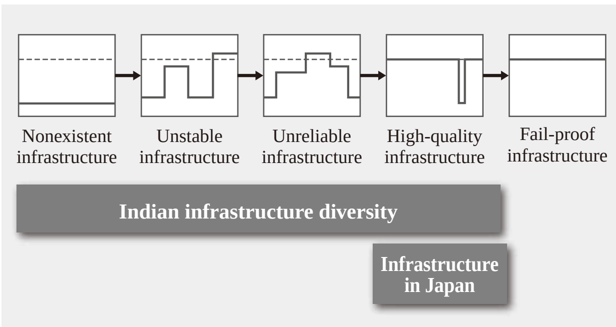

Fig. 1—Five Stages of Infrastructure Evolution.
Various stages of infrastructure evolution co-exist in India, unlike Japan where the infrastructure is of uniform high quality.

Given this picture, the question that arises is whether a control and information system that has evolved to operate social infrastructure at the fourth stage of evolution is ideal for a country in which stages one to four continue to co-exist. Or, whether it is necessary to redesign the system to handle a situation of diversity, so that it can cope with stages one to five collectively.

This article describes the issues facing research and development of this social infrastructure in India, and how Hitachi is active in this field.

REDESIGN FOR DIVERSITY

Redesigning for diversity, or diversity innovation, can be considered an alternative to merely adapting an information and control system for social infrastructure to fit the regulatory or affordability needs of the Indian market. The following sections describe three key points to consider when redesigning.

Design for Mass Customization

Diversity in the market may result in a range of expectations for the cost and features of an infrastructure system and its components. Whereas one segment of the market may place a priority on efficiency and reliability, another may be satisfied merely with functional compliance at an affordable price. Having a design that can be customized using variant and configuration management tools to address this variety of requirements in India provides a competitive advantage. One possible solution is to use a single information and control system design that can be scaled up or down to meet the needs of the nonexistent, unstable, unreliable and high-quality stages of infrastructure evolution. This can be achieved by reviewing and re-organizing the software and hardware architectures for re-configurability and mathematical modeling. Since a significant portion of the technology in information and control systems resides in the software and algorithms, one of the opportunities for mass customization is in software.

Krueger[(2)] describes several models for adopting software mass customization. The extractive model seeks to collect features from multiple products into a single product that may be configured to produce different variants, while the proactive model aims to produce new architectures or designs for a single product that can be customized through configuration. Although both the extractive and proactive models may be considered for redesign, the choice depends on the time and human resources available for the redesign work (see Fig. 2). Whereas the extractive model may be suitable when time and human resources are short, the proactive model is attractive for new products that may be candidates for reverse innovation with a long-term realization perspective.

When creating an architecture and platform that allow customization for Indian conditions, information systems require local intelligence and customization options because they must be able to function at the different stages of infrastructure evolution. If the control system hardware is to be manufactured locally, the following options for hardware redesign should be considered to enhance affordability and reduce the risk of obsolete components.

(1) Redesign the hardware platform to support critical components from different suppliers. In his

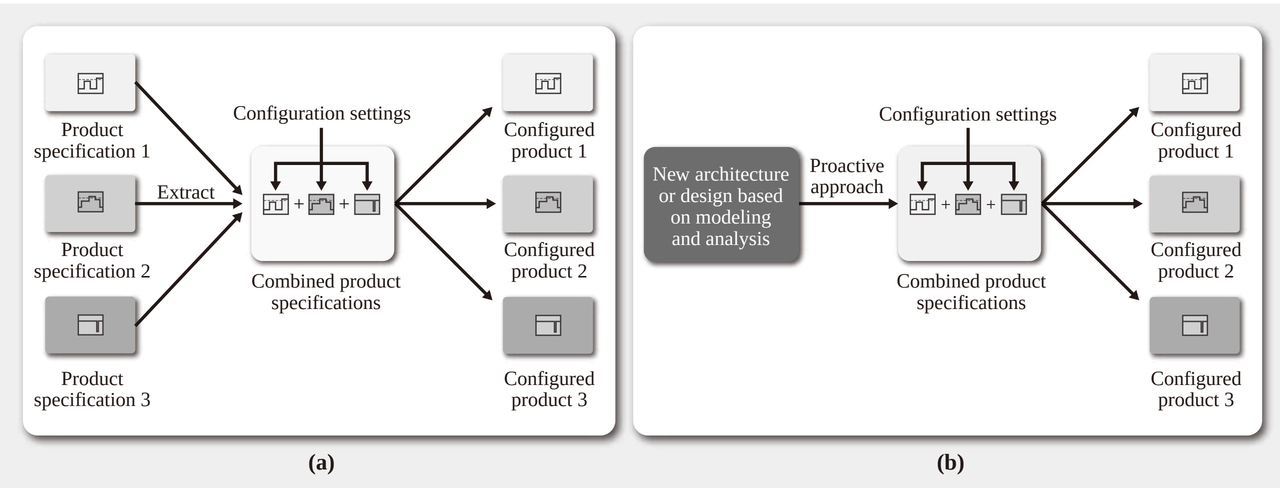

Fig. 2—Krueger's Extractive (a) and Proactive (b) Models of Software Mass Customization for Indian Infrastructure.
To create variant configurations, the extractive model involves studying existing products and features whereas the proactive model involves upfront innovation and analysis to create new architectures.

framework for industry analysis, Porter[3] lists the bargaining power of suppliers as one of the five factors affecting competitive intensity within an industry. One possibility for dealing with Indian market conditions, where Hitachi systems must be affordable to be competitive, is to redesign the hardware platform to allow the use of components from different suppliers. (2) When functional compliance is a key consideration and provision for scalability is required, it may be possible in some cases to make more affordable product variants by using mathematical modeling to substitute for non-critical sensors.

In one example, Infrastructure Systems Group, Hitachi India Pvt. Ltd. is promoting smart grids, railway traffic management, and intelligent water systems, and is considering a redesign of control boards to suit local conditions and allow mass-customization of the hardware and software for the Indian market.

Design for Immunity

Every control system design starts by defining the input-output characteristics. Control system equipment designed for high-quality infrastructure assumes that inputs (such as voltage, current, and frequency) will have a certain level of quality. In an environment in which infrastructure at all four evolutionary stages co-exists, however, systems must be designed to tolerate a lower quality of inputs. In the case when the hardware platform has been redesigned to use components from a wider range of suppliers, as proposed above, it may also be necessary to design the system to tolerate component malfunctions. Faults can have a range of severities and can be categorized into three groups based on fault location: (1) at the source or input side, (2) at the load or output side, or (3) inside the system at the component or sub-system level (see Fig. 3).

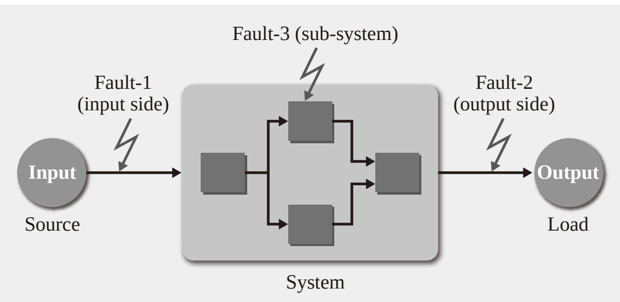

Fig. 3—Types of System Fault from which Immunity is Required. Faults can occur on the input side, output side, or in internal sub-systems. Systems must be designed for immunity to these different types of fault.

Under Indian conditions, the characteristics of inputs and outputs are unpredictable and the failure modes of locally procured components and sub-systems are uncertain. Accordingly, technology that is able to, (1) proactively sense fault severity for each of the above three fault locations, and (2) continue to function even if a fault occurs, or raise a timely alarm, has added value because it extends equipment life. Dominant designs often use technology of this nature. Normally, a new system must deal with the sensing infrastructure that is already in place. However, opportunities may also exist for dynamic configuration of control systems so that this proactive sensing and fault immunity can be achieved remotely.

An example is Hitachi Hi-Rel Power Electronics Pvt. Ltd., which supplies inverters and drives throughout India. While one installation may have few power outages per year and acceptable limits of transients and total harmonic distortion (THD) on both the source and load, another installation may have frequent daily power outages, as well as excessive transients and THD on the source or load that affect the life of the power electronics devices in the system. One way to deal with this is to incorporate a dynamic control system into the controller module that can learn the disturbance characteristics and provide case-based immunity (through active filter variants) or general immunity for worst-case scenarios.

Interface for End Users

"Poka-yoke" is a Japanese term in global use that means fail-safing systems to prevent them from being operated incorrectly. However, there is also a need to identify concepts that promote effective use of a system independently of the diversity of operating conditions. Once commissioned, a social infrastructure project must function within society, and the effectiveness of its use is dependent on factors such as regional culture and literacy. Another consideration when redesigning is to provide a user interface that can cope with the diversity of the Indian population.

An example of this is the Hitachi NeST Control Systems Pvt. Ltd. Operators who work with this distributed control system (DCS) used by Indian power utilities prefer pictorial and animated representations of processes. Another unique requirement cited by an Indian utility was to modify the user interface so that users could not open any other applications installed on the personal computer, because of their potential to distract an operator on duty.

In India, social infrastructure users may have different user interface needs, and catering to these may enhance their experience. Some of these differing needs can be satisfied using the mass customization variant configurations described earlier in this article. Other special requirements can be incorporated by involving the user in the design process. A simple tool chain could be developed to help users self-design the user interface of the Hitachi information and control system, with provision for necessary authentication.

RESEARCHERS FOR DIVERSITY INNOVATION

Having discussed the challenges and possible methodologies for managing Indian diversity by redesigning, the next important question is to identify appropriate human resources for this redesign work.

Local researchers who have both explicit and tacit understandings of this diversity are ideal candidates for diversity innovation. The redesign process involves extensive regional data gathering along with multi-modal and multi-lingual local communication, and also requires mathematical skills for modeling and simulating the unstructured regional data. Key points are listed below:

(1) India as a country has rich mathematical skills and a multi-lingual society. Local researchers may be able to offer several answers to the diversity challenge.

(2) One of the objectives of Hitachi India R&D Center is to enhance its research network through academic collaborations with institutes of international repute, such as the Indian Institute of Technology (IIT) and Indian Institute of Management (IIM). Recruitment of talent from institutions such as these may enhance this collaboration.

(3) Hofstede[4] uses five dimensions to categorize national cultures (see Fig. 4). A key difference between India and Japan is in the dimension of uncertainty avoidance. This implies that Indian culture is better at handling ambiguity and uncertainty than is Japanese culture, which encourages strict codes of conduct and behavior. For diversity innovation in a country like India, a low score on uncertainty avoidance may be an essential cultural trait.

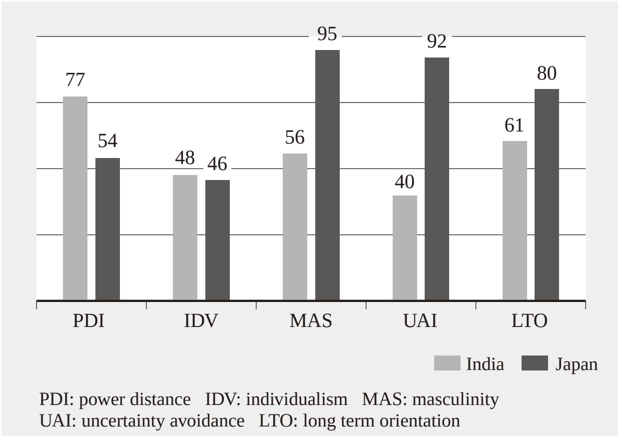

Fig. 4—Comparison of India and Japan Using Hofstede's Criteria.
Uncertainty avoidance appears to be the key difference when comparing the national cultures of India and Japan.

CONCLUSIONS

This article has described the issues facing research and development of social infrastructure in India, and how Hitachi is active in this field.

Businesses considering entry to the social infrastructure market in India need to consider diversity innovation, which means redesigning systems to support multiple stages of infrastructure evolution rather than merely adapting them to the conditions. This redesign must focus on meeting the diverse requirements of the Indian market through a common platform that supports mass customization, immunity to operating environment, and an interface suitable for use by diverse user groups.

To ensure that its research and development can continue to innovate in ways that match the market's diversity, R&D Center of Hitachi India Pvt. Ltd. is seeking to recruit talented local researchers with a thorough understanding of the variety of regions and markets that make up India.

REFERENCES

(1) Planning Commission, Government of India, "Approach to Twelfth Five Year Plan" (2011).
(2) C.W. Krueger, "Software Mass Customization," BigLever Software, Inc. (Mar. 2006).
(3) M.E. Porter, "The Five Competitive Forces That Shape Strategy," Harvard Business Review (Jan. 2008).
(4) G. Hofstede, "National Culture," http://www.geert-hofstede.com/

ABOUT THE AUTHOR

N. Vinoth Kumar
Joined Hitachi India Pvt. Ltd. in 2011, and now works at the R&D Center, Hitachi India Pvt. Ltd. He is currently involved in social infrastructure research planning.