The Intelligent City and Emergency Management in the 21st Century

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ABSTRACT

The emergence of the intelligent city in the 21st century will radically transform emergency management as we know it today. Computing and telecommunications technologies, once separate and well–defined, will merge and their distinctiveness will blur. Mobile wireless and Metropolitan Area Networks (MANs) will serve as the telecommunications backbone over which municipal management information systems will synchronize and orchestrate the various functions of government agencies and departments. Traditional organization and separation of municipal departments and agencies will undergo significant change as the intelligent city makes interdependent relationships more concrete and dynamic. Resource allocation will become more efficient as implementation of comprehensive planning becomes more tangible. Rather than existing largely as a separate and distinct function which is called upon during times of crisis as it is today, emergency management will become integrated into every facet of municipal planning and operations. The intelligent city will incorporate each of the elements of emergency management (preparedness, response, recovery, and mitigation) into its overall planning and operational matrix.

INTRODUCTION

In the hundred years or so since its introduction, the automobile fundamentally changed the world, its effects can be seen having shaped both cities and institutions. Similarly, digital technologies, which are still in the their genesis, will, over time, have impacts of equal or greater magnitude, reshaping our cities and institutions. The role of emergency management in ensuring public health and safety will be modified by the coming changes. What form these changes will take can be surmised by evaluating trends in emergency management, government, industry, education, telecommunications, computing, and cybernetics.

CYBERNETICS, AUTOMATION, AND INTELLIGENCE

The field of cybernetics holds the key to the intelligent city. Cybernetics is the study of control and communication processes in electronic, mechanical and biological systems. Cybernetics has the ability to synthesize and simulate intelligent systems and can provide the means for improving planning, decision–making, and problem–solving processes, in some cases automating them. Introducing automation requires planning, which implies prediction and control, all of which requires communication. The emphasis in design and planning within the context of applied cybernetics in the intelligent city will be flexibility, with a built–in capacity for change. The total system will be dynamic, where various subsystems can adjust as required to maximize the well being of the whole system. Such adjustment will be affected by a concept in cybernetics called "negative feedback", wherein systems modify their behavior in light of changes in the environment. Real–time modeling will occur whereby subsystems can run "what ifs" and then feed the results to a central processor which compares all subsystem results and passes either positive or negative feedback to subsystems. The desired results of one subsystem will thus be in relation to all other subsystems affected. An optimized condition is reached when all subsystems therefore act as one toward achieving the desired goal. Lack of organization, interagency conflict, inefficient use of resources, and other problems oftentimes encountered in emergency management will no longer be commonplace. In a reductionist sense, many of these problems can be attributed to barriers of time and space which are rapidly breaking down.

THE CITY AS AN ORGANISM

To better understand the concept of the intelligent city it is helpful to draw an analogy with the natural world. With 13 billion years to equilibrate and optimize, natural systems are a superior model for perfecting manmade systems. Organisms naturally tend towards homeostasis, a condition of physiological equilibrium produced by the balancing of functions within the organism. In homeostasis a change of state in one part of the system elicits a response from other parts of the system to maintain balance. The intelligent city will, in many respects, operate very much like an organism, monitoring its various component systems and responding accordingly to potential or actual changes of state in order to maintain equilibrium. This sensitivity to potential or actual changes affecting the equilibrium of the city will have important ramifications on emergency management. As conditions favoring disaster are detected, the intelligent city will respond accordingly, heightening readiness as appropriate. The intelligent city will assimilate knowledge of hazards and implement hazard mitigation as an integral component of its overall functionality. As feedback processes are built into the intelligent city, the system will learn from its mistakes and improvements will occur. This learning capability already exists today, albeit in a rudimentary form, in neural networks.

When an organism experiences a pending or actual change of state, information is distributed among and between all other parts of the system and changes are made accordingly. For example, if food is absent, the metabolic rate might slow down as the organism seeks homeostasis. Similarly, when a city is threatened by a pending or actual hazard which puts lives and/or property at risk, emergency managers interact with different departments and agencies in anticipation of changes which must be made to reduce losses or avoid them altogether. Emergency management is basically all about managing and coordinating a complex system. While the organism has a highly responsive information collection and distribution system consisting of a brain and nervous system, the city as we know it today does not. The vulnerability of man's artificial environment exists today because of the absence of an effective communication and control system, creating a permanent condition of asymmetry which leaves society open to disasters. As telecommunication and computing technologies are used to interconnect all municipal subsystems, the city's nervous system will be in place and a condition of equilibrium will be defined. The responsiveness of the city to pending or actual changes will then improve, as deviation away from the optimal condition will be both predictable and correctable.

If we view the intelligent city like an organism, experiencing countless actions and reactions, we can see that unless these actions and reactions are intelligently managed and coordinated, then the system experiences chaos and crisis. When an outside force such as a natural hazard acts upon the system, a disturbance in the system occurs, upsetting the balance and chaos ensues. Catastrophes are the ultimate expression of a natural hazard acting upon a system made vulnerable due to the absence of an effective control and communication system. In point of fact, our definition of a hazard – implying undesirable qualities – is only in relation to the effect it has on our artificial systems. A value judgment is being made. A hurricane is not intrinsically bad, we only view it as such because of our poor adaptation. A good example of this is our proclivity to develop in the floodplain.

In a sense, our disasters are evidence of our failure to model ourselves after biologic systems. The refined control and communication systems in species are principally manifested as self–control, i.e. adaptation, which sometimes implies withdrawal from harmful environments and acclimatization to more favorable ones. In manmade systems this could mean passive acceptance of the hazard (e.g. purposeful undevelopment allowing high hazard areas to revert back to their natural state) rather than active resistance (e.g. strengthening building codes).

TOOLS AND TECHNOLOGY

High bandwidth capacity provided by a combination of both wire (including fiber) and wireless transmission mediums will make connectivity "anytime, anywhere" a reality. Data speeds in the gigabyte and terabyte ranges will carry two–way audio, full motion video, and text between both stationary and mobile locations. Telecommunications and computers will merge, becoming nearly indistinct, and will link the various subsystems of the city, e.g. transportation, energy, waste, etc. through a MAN (metropolitan area networks) into an overall system imbued with intelligence. A single knowledge base, feeding and being fed by numerous subsystems, will serve as the "brain" of the intelligent city. For example, in the event of an emergency, traffic patterns will be changed automatically to permit orderly evacuation and/or rendering of aid. Spatial intelligence, combining information provided by next generation GPS and GIS, will drive radiodirection, radiolocation and navigational guidance systems to pilot vehicles and regulate and disperse traffic flows. Technology for storm prediction and tracking will improve, increasing the reliability and accuracy of preparedness

activities (e.g. warning and evacuation). Automated forecasts and historical data will be matched and likely scenarios will be plotted. Computer aided education and simulations using virtual reality will be used for training exercises. Emergency warning and notification systems will extend into the home and the workplace, taking advantage of the "anytime, anywhere" model of connectivity.

Intelligent Assistants

While decision–making in emergency management can frequently make the difference in a life or death situations and we would not wish to place exclusive trust in an automated system, certainly processing the many variables which rapidly change during an incident is beyond human capability and this is where a certain amount of automation can be helpful. Such automation is the domain of the "intelligent assistant" a revolutionary tool for aiding people who perform tasks which cannot be automated.

The intelligent assistant will be the result of combining expert systems, decision support systems and artificial intelligence. They will be portable, appliance–like and will utilize natural language processing and voice recognition. They will be useful for problem solving, outlining emergency procedures and role clarification. The intelligent assistant will be utilized to make situation reports and will provide specific guidance to the user on task ordering and completion. The plethora of incoming reports which are common during crises will be machine filtered, undergoing preliminary checks for accuracy and reliability, then passed onto the emergency manager for consideration as part of his/her decision support system. Situation reports will be fed into the cities' common knowledge base where modeling will occur. Predicted outcomes along with actual and suggested interventions will be implemented and communicated via the cities' control and communication systems. Information on damages and losses will be captured and immediately translated into resource requirements for both response and recovery. Crisis events will be recorded in great detail, capable of replay for simulations and training purposes.

HUMAN FACTORS

It is fairly certain that in the future, public debt, insurance industry losses, and the trend toward greater societal equity will result in an increase in the responsibility the individual bears for his or her actions upon society. Institutions which currently absorb and then spread losses (government and insurance) across society will undergo a transformation as society systematically goes about the business of mitigating hazards rather than creating or sustaining them. How much of this will occur through legislation and how much will occur through market forces can not be known at this time.

As the impact of control and communications systems become widespread, there is a danger of their misuse along totalitarian lines. The dangers of control and conditioning have been amply described in George Orwell's *1984* and Huxley's *Brave New World.* Subtle intrusiveness of sensing and monitoring functions in the intelligent city will create a tension between the rights of the individual versus the well–being of society. Issues of privacy need to be balanced with monitoring activities of people. There is no denying that control can be a threat to civil liberty. In the interest of society, however, it is possible that a reforging of what constitutes the unalienable rights of the individual will occur.

While change may bring about prejudice in people affected, feedback processes in the intelligent city will be personalized to mitigate such adverse reactions. As individuals learn more about how they affect and are affected by others, resistance to change will diminish.

In addition to simple adaptation from negative feedback (reactive), complex adaptation through learning (proactive) is also possible and has the greatest potential for avoiding damages and losses in the future. The lag time between the gaining of new knowledge through experience and the dissemination of that knowledge in ways to effect change will be reduced considerably by improved information capture, processing and distribution. Maintenance learning, i.e. maintaining the status quo, will give way to innovative learning. The separation of education and work will end and the two will become almost indistinguishable from one another. This will occur for three reasons: 1) real learning is experiential, i.e. on the job; 2) the time lag between gaining new knowledge and its implementation is wasting valuable resources; and, 3) a measurable return on investment in creating new knowledge must be gained if further investment is to take place. This has important implications for emergency management in extending hazards reduction into all phases and aspects of society.

GOVERNMENT AND CHANGE

The future of state and local government will be shaped by a combination of forces, including technology, politics, economics, demographics and environmental changes. As

futurist Alvin Toffler has indicated in his book *The Third Wave*, strong leadership will be replaced by local and individual action. Government will provide the resources, especially the learning mechanisms, to equip individuals for their increased responsibilities. Government will encourage self–sufficiency in preparedness, response, recovery and hazard mitigation within individual neighborhoods and communities. Government will become less top–heavy, more flat and decentralized, following similar trends in the economy and business sectors. Continued decreases in federal aid will demand that local governments realize greater efficiency and look for economies of scale in service delivery. This will be accomplished by increased privatization of public services and government stimulating self–sufficiency at the local level. Geologic, fire, wind, and flood hazard districts will be created to raise funds for hazard mitigation. Citizens will have more control over the activities of government which affect them. Citizen access to government will increase through direct participation in decision–making via telecommunications, making most, if not all, representative forms of government obsolete. Governments primary job will be to inform and educate.

Local government has become more complex and fragmented. At best departments don't work in concert, at worst their objectives are at complete odds with one another. Applied cybernetics will eliminate the incongruities between government agencies, operating not in isolation but in relation to all other departments and agencies within government.

CONTINUUM AND SUSTAINABILITY

By necessity, planning will play a critical role in the design and development of the intelligent city. Hazard identification will be incorporated into the fabric of infrastructure design, planning and operations. Agency actions will be in concert with one another throughout the municipality as decision–making and plan "checks" will occur with every other agency in the municipality. Within this matrix, planning and operations are a continuum, feedback and corrections are immediate, and accommodation or rejection of innumerable actions take place. Crises either have their origin in nature, or occur through unintentional and impersonal factors inherent in human agency. The intelligent city will detect ever earlier stages of the causations of crises, enabling us to better prevent or minimize them. The relationship between risk and cost will be better understood and individualized. Mechanisms for mutual aid will improve, as cities and states will be linked through what is now taking shape under the guise of the "national information superhighway". Through these interconnections cities will compare experiences and learn from one another. Vulnerable infrastructure in high hazard areas will be identified and systematically retired.

CONCLUSION

Within the intelligent city, emergency management will become more proactive rather than reactive as it is today. Emergencies will occur with less frequency in the intelligent city as "unexpected situations" or "sudden occurrences" will decrease with applied cybernetics. Virtually all of the technologies necessary to construct the intelligent city have already been introduced, albeit some (e.g. natural language processing) in rudimentary form. Technological forces in computing and telecommunications have already precipitated dramatic changes in the manner and style in which cities operate. While we are in the infancy of consciously merging the various components, the groundwork for the intelligent city is already being laid, changing the municipal landscape and transforming both the theory and practice of emergency management forever.

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