ITS and Smart Grid Networks for Increasing Live Shellfish Value

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Abstract

Intelligent transport systems (ITS) non-safety capabilities along with the development of next generation grid-based vehicles will continue to play a fundamental role in the development of new applications that can impact logistics and supply chain management operations. The principles characterizing non-safety ITS applications can be developed to increase the reliability and visibility of supply chains in key sectors such as food in small urban and rural areas. More specifically, a supply chain visibility solution for seafood transportation can be designed to include specialized intelligent seafood transportation containers, which represent mobile wireless nodes capable of sending information via vehicle to infrastructure (V2I) about the status of live seafood stock. The expansion of the smart grid in rural and small urban areas will provide the support for the deployment of ITS applications that can impact the perishable food value chain.

Keywords:

smart grid, VANETs in small urban and rural areas, seafood sector..

Introduction

The expansion of the smart grid and intelligent transport systems (ITS) offers unique opportunities and challenges comprising the definition of a common network platform to be used in the deployment of future commercial services. The smart grid has been defined as an ‘electricity network that can cost efficiently integrate the behavior and actions of all users connected to it in order to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety’ (ERGEG -European Regulators’ Group for Electricity and Gas, 2009). A typical smart grid configuration includes various elements such as residential users, office buildings, factories, warehouses, electric vehicles, renewable sources, transmission lines and traditional sources of power such as hydroelectric and coal-fired power stations. This group of consumers and producers require the use of a wireless network platform where meter readings and data can be transmitted. The European Commission (2011) in its European Energy Strategy 2020 has acknowledged the need to work towards the deployment of the future European electricity networks using the latest technology. According to the European Commission's view, electricity will be delivered where and when needed, and consumers will be able to monitor their electricity consumption in real time. The other key component, ITS, is based on the use of advanced information and communication technology to achieve a reduction of congestion and accidents while making transport networks more secure by reducing their impact on the environment (Zomer and Anten, 2008).

Research work involving the use of the smart grid and ITS in small urban and rural areas does not get much attention compared to research work carried out in big cities and large urban areas. As it is the case in large urban conglomerations, in small urban and rural areas the smart grid relies on the use of network platforms where meter readings and data can be transmitted. Moreover, transportation needs of small urban and rural areas making use of the smart grid can also be addressed with intelligent transport systems (ITS). ITS relies on the use of network platforms based on vehicle ad-hoc networks (VANETs) in addition to the use of available technologies such as cellular networks, Wi-Fi or 3G. Given the magnitude of the challenges faced by both the smart grid and ITS in several fronts there is enough evidence to support the study of a common platform capable of supporting future services in small urban and rural areas. VANETs are particularly important to the development of ITS applications as these are expected to grow and evolve with the ultimate goal of achieving an accident-free driving environment (Faezipour, 2012). However, one key advantage is that VANETs can handle different types of service applications, including the transmission of both safety and non-safety messages into two modalities: vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). The handling of different types of service applications for safety and commercial purposes is one capability of VANETs that will continue to grow in importance due to the development of the next generation of grid-based electric vehicles characterized for not only drawing energy from the smart grid, but also the storage of energy to the grid and allowing various data communication (Faezipour, 2012).

The possibility of developing robust solutions for business and commerce using VANETs is enormous as the same principles characterizing the operation of non-safety ITS applications can be applied to the development of solutions outside road safety and traffic control with the potential to increase the reliability and visibility in the management of supply chains. In essence, intelligent containers which might use a common platform supporting the smart grid and ITS would be able to relay information about the status of the cargo to various players including haulers, logistic operators, insurance companies, cargo owners and end users.

Furthermore, several industry sectors can benefit from the reliability and visibility that the smart grid and ITS can provide to logistics and supply chain management.

This paper addresses the development of a common platform of ITS applications and the smart grid, for the purpose of improving the visibility of seafood supply chains. More specifically, the focus is on the supply chain of live high value shellfish crustaceans (shellfish). In this paper a framework based on the principles of ITS and smart grid is used to present a concept solution, the base for new development/idea for the transport of live of shellfish. The solution envisaged contemplates having specialized intelligent seafood transportation containers, which represent mobile wireless nodes capable of sending information via V2I about the status of live seafood stock. The solution goes beyond the deployment of just intelligent containers as the expansion of the smart grid in rural and small urban areas will provide the support for the deployment of ITS applications that can impact the perishable food value chain.

Background of the seafood sector

Seafood and fishing can be classified as primary sector activities and traditionally these have been considered low-tech. According to the OECD (2005), low-tech industries account for the bulk of economic activities in developed and developing nations alike. The OECD definition of low-tech corresponds to those industries that devote on average less than 0.9% of their expenditures to R&D. Despite this fact, low-tech industries account for more than 90% of the GDP for Western European countries (Von Tunzelmann and Acha, 2005).

For a sector like seafood and fishing, the adoption of technological developments like the use of a common platform incorporating the smart grid and ITS applications for the purpose of improving the visibility of the supply chain represents a paradigm change due to the introduction of innovations. Early studies in the field of technology management in the seafood and fishing industry have described mixed dynamics of innovation. According to Levine and McCay (1987) innovation in the sector is generated mostly in the way fish stock is catch and how is catch. Furthermore, they emphasize the fact that innovation and technological change is driven by the perception of the future. In a more recent study, Robertson and Smith (2008) clearly demonstrated the increasing technological sophistication in the fishing industry, tough still perceived as being low-tech. According to Robertson and Smith (2008, p.112), current fishing technology includes the embodiment and adoption of applied technologies in domains such wireless communication, radar, sonar, optical technologies, robotics, fluid dynamics and material science.

The increasing technological sophistication experienced in the seafood and fishing industry now covers the entire logistics and supply chain activities. Talking about innovations, the consolidation of the temperature-controlled chain is perhaps one of the major innovations/developments that have affected the food chain. Basically, the temperature-controlled chain like the cold chain is a supply chain where temperature is under control. Kuo and Chen (2010) identify that the consumer awareness of food safety and government food safety regulations are the major driving forces behind cold chain development. Furthermore, the authors point out that customers expect that the products they order can be received safely, freshly and on time as any temperature changes during the logistics process may cause loss of flavor or even spoilage.

Zhang et al. (2003) identify that one of the particular attributes of the logistics systems for chilled and frozen goods is the maintenance of product quality, which is dependent on the duration of delivery time and variation of temperature in the temperature-controlled chain. Kuo and Chen (2010) added that the physical logistics system of a temperature-controlled chain is configured to minimize the cost of storage and transportation, and to meet the requirements of product quality. However, the temperature-controlled chain requires additional capital investment in the forms of storage and transportation facilities, which ultimately reflects in higher operation costs.

A temperature-controlled chain solution comprising the use of intelligent containers for the transportation of seafood might require the use of a common platform supporting the smart grid and ITS to relay information about the status of cargo to various players including haulers, logistic operators, insurance companies, cargo owners, retailers, catering companies and restaurants. The development of ITS non-safety applications can be used to forward critical information about the status of perishable transported goods, in this case high value shellfish crustaceans. ITS applications supported by VANETs, can be used to forward the status of seafood transported (namely, lobster or live fish) stock to harvesters, logistics providers, distributors, retailers and end consumers.

Seafood products such as lobster, and other high value and perishable shellfish, products retain higher value alive rather than butchered. Hence, a technology that has the potential to increase the survivability rate of shellfish products during transportation (especially for long haul ground trips) could be very beneficial to many parties including harvesters, logistics providers and end users such as retail and restaurants (Coronado and Coronado, 2012). In temperature-controlled chains, innovations in the transportation of live fish and shellfish have mostly been concentrated on the development of incremental improvements in container technology. Hence, the need for robust solutions where survival conditions need to be monitored to minimize the mortality rate of transported seafood stock animals and which can be handled by non-safety messaging capabilities present in VANETs. Survival conditions that need monitoring include:

- Quality of transported animals
- Adequate amount of dissolved oxygen
- pH, Carbon Dioxide and Ammonia
- Water temperature
- Activity and quantity of animals transported

A basic representation of the type of solution envisaged is presented in figure 1. In this environment the transport of high value shellfish products is fully dependent on a smart grid base defined as the smart grid backbone which is linked to critical elements such as warehouses, power stations and transport vehicles. The warehouse is where the shellfish is prepared, put in containers and dispatched and at all times survival conditions are monitored. This monitoring is extended during transport where the vehicle receives and transmits information to/from roadside units next to a power station linked to the smart grid.

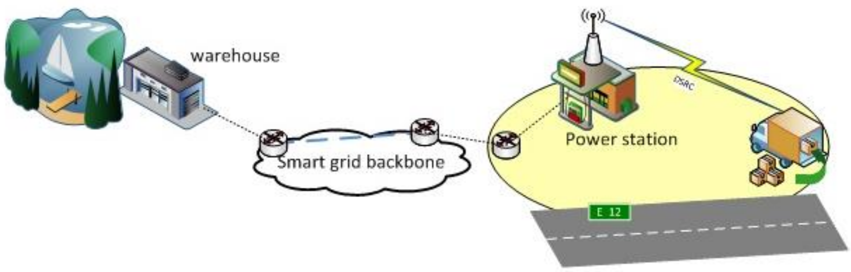

Figure 1. Smart grid backbone linking warehouses, power stations,

The presence of the smart grid in rural and small urban areas will provide the support for the deployment of applications that can be used in the transport of seafood and other perishables which require the use of a temperature-controlled chain.

Elements comprising a solution for live seafood transportation based on ITS and the smart grid.

Critical survival information of transported live seafood stock is fundamental in the development of any solution that makes use of a common smart grid and ITS network platform. The resulting supply chain visibility supported by a common smart grid and ITS platform will enable seafood harvesters and end users with access to real-time and historical information on the conditions of transported animals such as water temperature, dissolved oxygen, salinity, pH and water temperature information. Moreover, the enabled visibility will enable a better understanding of the dynamic biophysical conditions influencing the survivability of transported animals will be useful for harvesters, logistic operators and end users to better control their value chain and will allow better decisions on improving the transportation of these animals. Figure 2 depicts the layers that comprise the common ICT platform for the smart grid and ITS based on the use of VANETs.

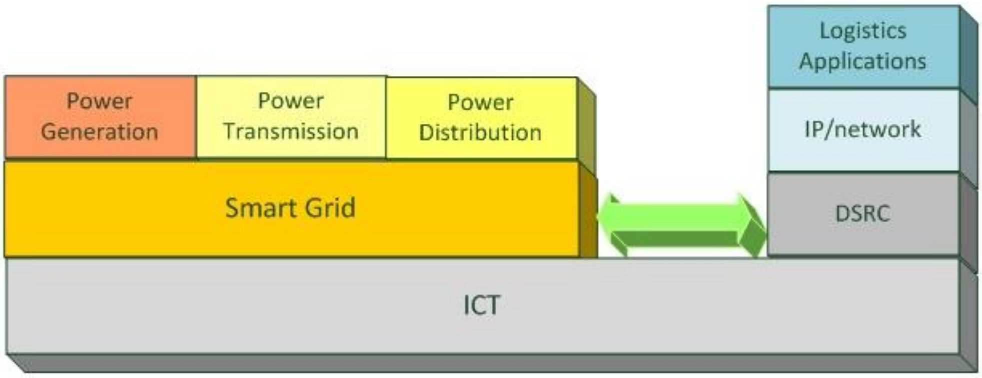

Figure 2. ICT is the common layer to support the smart grid and ITS using DSRC-based VANETs

In figure 2 the proposed use of ITS is represented by a Dedicated Short Range Communication (DSRC)-based VANET. The smart grid comprises three key elements: power generation, power transmission and power distribution. In the case of the DSCR-based VANET the upper layers comprise a layer for IP/networks and on top a layer for applications which include logistics and supply chain management. Regarding the use of VANETs, Dedicated Short Range Communication (DSRC) is a next generation wireless vehicle network technology with an increasing role in ITS and with the potential to also meet the needs of the smart grid. The basis for DSRC is the amendment to the IEEE 802.11 set of standards for wireless local area networks (WLAN IEEE 802.11p) which adds wireless access in a vehicular environment (WAVE), giving the opportunity to develop innovative applications and services. The 802.11p standard is set to pave the way to provide wireless channel specifications for roadside to vehicle (vehicle to infrastructure, V2I) and vehicle to vehicle (V2V) communications environments. DSRC technology operates in the Super High Frequency (SHF) Band at 5.9 GHz (Zhao, Kivinen, Vainikainen, & Skog, 2002).

The functionality of the common platform linking the smart grid infrastructure with the ITS DSRC-based VANET infrastructure integrates the functionality of the logistics infrastructure. The logistics infrastructure layer, which is at the uppermost level of the common platform, hosts the applications for the purpose of monitoring the survival conditions of live shellfish. Figure 3 depicts the interaction between the smart grid infrastructure, the ITS infrastructure (DSRC-based VANETs) and the logistics infrastructure. Between the smart grid and the DSRC-based VANET the flow of data is represented by consumption data as power is drawn towards the ITS and logistics infrastructures. In opposite direction optimization and planning goes from the application hosted at the logistics infrastructure towards the ITS and smart grid infrastructure.

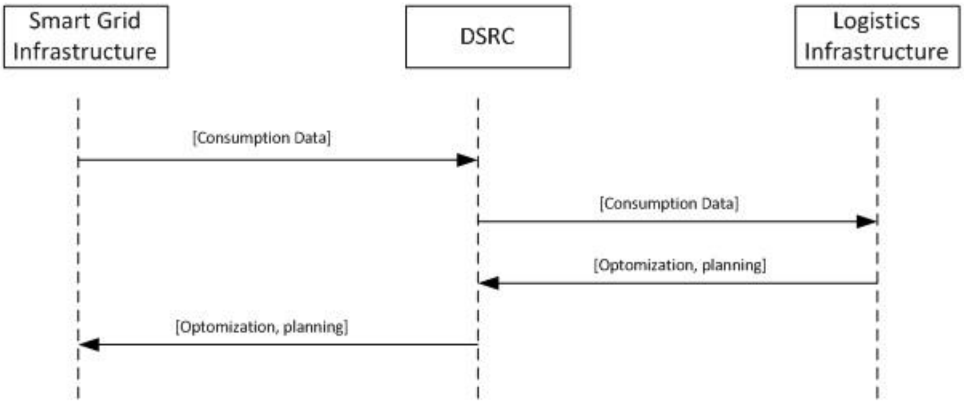

Figure 3. The interaction between the smart grid infrastructure, ITS infrastructure (DSRC-based VANETs) and the logistics infrastructure

The elements comprising the smart grid infrastructure, ITS infrastructure and logistics infrastructure interacting can be seen in figure 4 where various of these elements participate including industrial users, factories, transport vehicles, power plants, transmission lines and distribution substations. All of these as elements of the smart grid will require the use of a smart grid IP backbone where meter readings and data can be transmitted

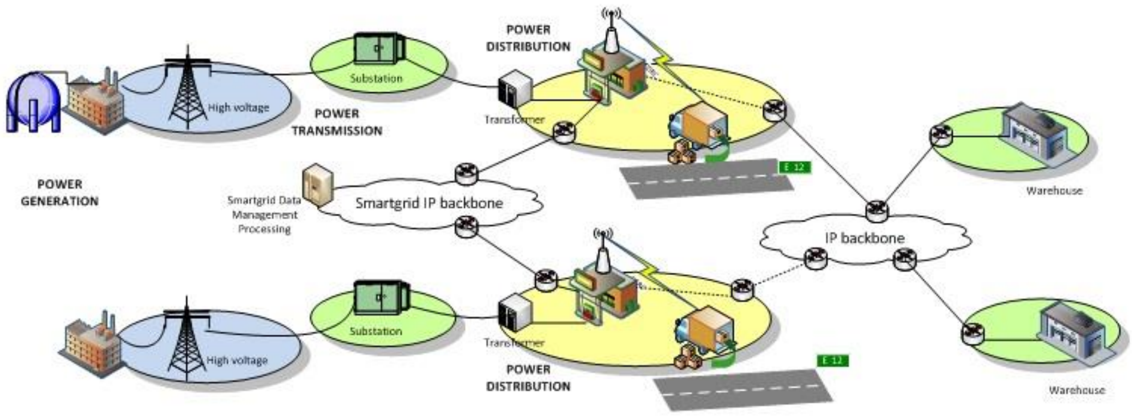

Figure 4. Various elements communicating through the smart grid backbone

To the best of our knowledge, the authors are not aware of any similar solution to increase the visibility of supply chain for shellfish products combining both the capabilities offered. The transport of seafood as well as other perishables requires controlled temperature environments. In the cold chain, efficient refrigeration for controlled temperature transportation of seafood might be achieved through the use of a common network platform supporting the smart grid and ITS. Moreover, small urban and rural areas which are the main locations of seafood production will be impacted by the use of a common smart grid and ITS network platform as well. This solution has the potential to increase the service offered by operators (increase in traffic) to a wider customer base at a minimum cost. Furthermore, it open up the possibilities to increase the visibility of other supply chains with resulting benefits that include increased reliability, increased data traffic, etc. We believe end users that will benefit from this application include small rural fishing communities which depend on the fishing of shellfish crustaceans.

Conclusions and future work

The output of the research has the potential to become a source of reference by policy makers when it comes to defining the strategies and work plans that will be needed pertaining the adoption and full deployment of a convergence network platform for the smart grid and ITS in individual countries or economic blocs such as the EU. At the same time it will contribute to expand business opportunities within the seafood, retail and catering sectors. Another aspect to consider is that this application can make a contribution for sustainable fishing practices.

ITS non-safety capabilities along with the development of the next generation of grid-based electric vehicles will continue to play a fundamental role in the development of new applications that can impact logistics and supply chain management operations. More specifically, a supply chain visibility solution for seafood transportation can be designed to include specialized intelligent seafood transportation containers, which represent mobile wireless nodes capable of sending information via V2I about the status of live seafood stock, are necessary to transform and create markets for a seafood industry.

The route to impact for the development of this type of solution contemplates not only collecting data, mapping data traffic, analysis of economic outcomes and discussing the results with partners that facilitated data collection but also disseminating work-in-progress as well as to capture the input in the form of observations, questions, feedback, suggestions and overall scrutiny. The design and simulation of a network architecture for the smart grid and ITS and the possibility of future test bed trials are the subsequent activities that will follow the completion of this feasibility study. Also this research work has the potential to benefit small rural communities where their economies are highly dependent on the harvesting and commercialization of shellfish.

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