Information-, Control- and Energy Networking

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Problem statement

There is a tendency to connect relatively small closed or isolated systems (networks) into a large global networked system (network). An example of this development is the birth of the Internet from an initially small research network to a global ubiquitous communication and information network. Another example is the creation of large pools of distributed energy sources, which destroys the monopole positions of utilities and brings energy into a commercial open market. Interconnecting isolated networks has advantages but, as one can observe in daily life, also disadvantages. In information and energy providing networks it is enforced to allow "strangers" to use and sometimes even control the local facilities. In principle, the interconnection makes the users of sub-networks players in a global network and the *idea of privacy* is lost.

Relevant problems

Advanced communication, control and security technologies are needed to enable integration and interoperability functions. These include basic aspects regarding safety, security, reliability, cost, and customer acceptance. It is important to use existing technologies in an efficient and integrated manner and to gradually grow towards a new more global structure that possesses *transparency*. This must provide a real-time, interactive, customer-managed service network for an evolving infrastructure.

- Open, standard protocols are needed to provide interoperability, scalability, and re-configurability.
- There exists a high degree of dependability between communication, control and energy networking. Relations must be established to guarantee a robust, but yet efficient system. Quality criteria need to be defined with respect to cost, availability, redundancy, reliability, security, and privacy.
- To obtain a reliable service that is able to recover quickly from failures and to resist system attacks, the supporting services must be developed depending on the energy providing facilities. Furthermore, risk analysis should indicate the weak spots in the network and the costs of failures involved. An important aspect to be considered is the redundancy in the energy, communication and computing network.
- The networking management system should be capable of reacting real time on changing circumstances and use prediction and feedback to guarantee maximum service and interaction with the customer and application.

Analysis needed

Knowledge of the physical network and communication requirements are necessary for the development of new communication and control structures. Networking can be divided into 4 layers:

- Generation of Information, Energy, Mass;
- Transportation: intelligent networks take care of the transportation to distribution points;
- Distribution: delivery at the correct application or customer;
- Application/customer: the user.

Each of these layers has its own specific needs for communication, control and security support.

The relation between the layers must be determined in order to have an interaction between the need of the customer/application and the resources available. This aspect is indeed very important for the proper dynamical behavior and reliability of the network.
In modern networking, static networking becomes dynamic due to the marketing mechanisms introduced. This leads to additional problems for network management. One example is the key distribution problem in short time operations.
Communication also takes place at different levels: business oriented for local and global exchange of data for commercial purposes; networking control for service, control and management of devices and services, monitoring and emergency; application or customer level for service, management, monitoring. These communication levels all have their specific requirements in speed (bandwidth), importance, direction, etc, depending on their role in the network. The communication structure needs to be flexible and scalable.
Good modeling is necessary to be able to predict the network reliability. One has to find accurate models to describe dependability and the relation between for instance redundancy and Quality of Service.
In distributed systems, one can expect that control is also distributed and that communication is needed to combine local decisions and computational results. It is in general easier to compute locally than to communicate with a central server. Therefore, one needs to know the communication constraints and the knowledge to be transmitted for global control. Embedded systems are constrained in their capacity. The conclusion is that we have to establish a relation between the available restricted resources, the limitations put by the environment (EMC; available hard/software; power and bandwidth), the performance of these systems, and the non-traditional conditions.

Towards a solution

New techniques, like - the Internet, broadband communication, distributed and parallel computing, integrated information functionality -, can be used to enhance system performance and to create new possibilities for management and control. On the other hand, these techniques introduce new problems with respect to reliability and security. It is therefore necessary to investigate the risks and the inherent limitations for applications.
For monitoring and security enhancement purposes, one may use information from GPS (or the European variant for exact timing and location information), the Internet or the GSM network. It is obvious that the Internet can play an important role for communication purposes. It offers new and cheap solutions for networking problems. However, it is at the same time the most unreliable and unpredictable part of the communication chain. It introduces unknown security risks, allow hackers to enter the network and play games like blocking traffic and observing secret information flows. One has to consider security aspects of communications including Internet based applications.
Networking has private and public components. In private networking one may distinguish between wired (fiber, PLC) and wireless (Radio). In public networking we may consider to use GSM, Internet and GPS. The physical conditions bring in the cost and quality aspects.
There is a strong relationship between information flow and energy flow management. In modern meshed information networking, network redundancy plays an important role. An interesting development is the concept of p(rotective)-cycles providing redundancy in case of link and node failures. This concept can also be used in energy networking.

Conclusion

We consider a general approach to the connection of smaller isolated networks. In general, the mentioned problem is not restricted to technical networks, but also has relations to non-technical networks occurring in our modern global society. It can be refreshing to get the social sciences involved in the ongoing discussions.