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Sistemi di comunicazione per Smart Grid

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Smart Grid Technologies: CommunicationTechnologies and Standards

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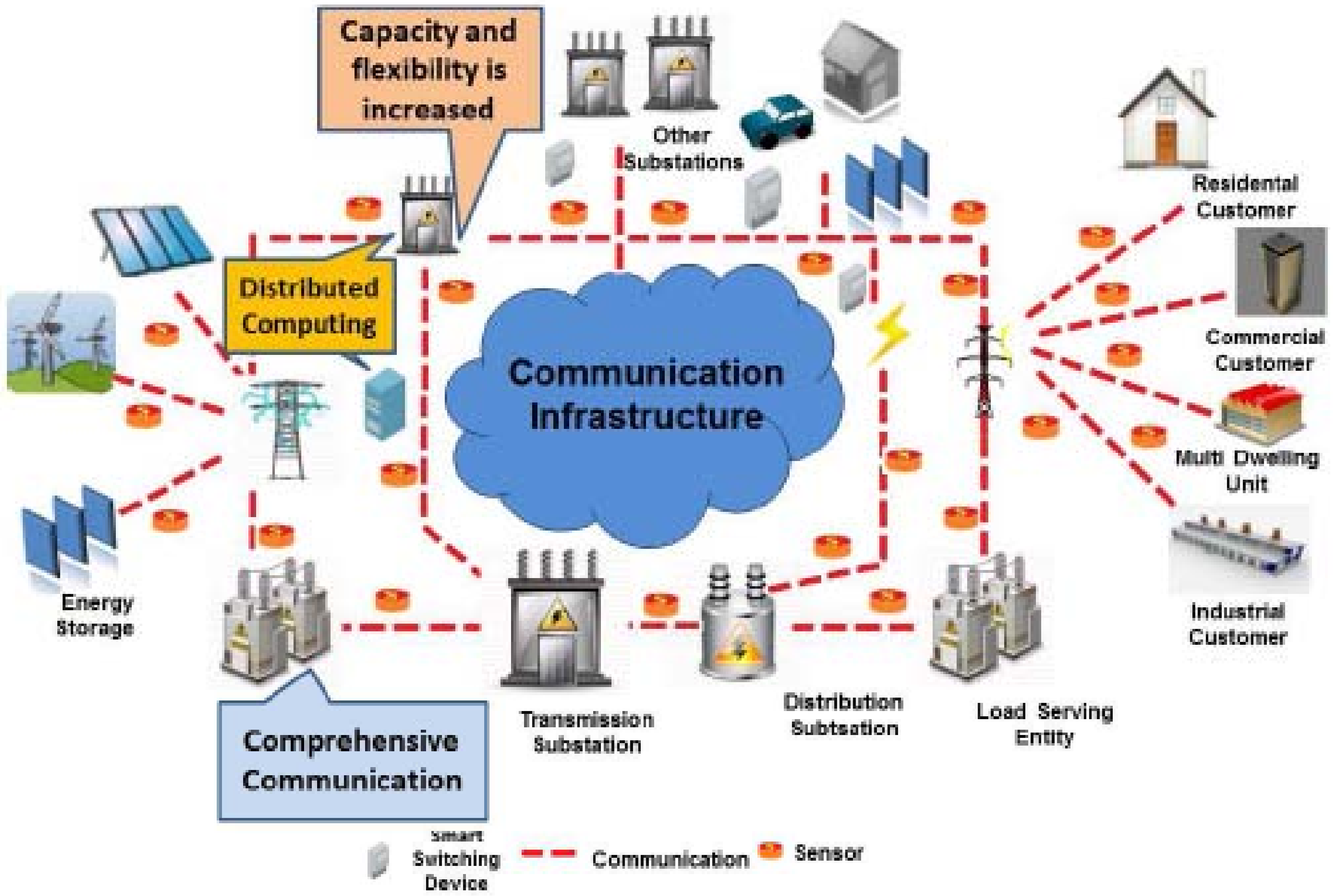
CARATTERIZZAZIONE ATTRAVERSO

- Supporti fisici e infrastrutture per la comunicazione
- Caratteristiche richieste alla comunicazione
- Standard adottati

Architettura e Sistemi di comunicazione



Esigenze di comunicazione. Perché …

Gestione efficiente e vantaggiosa economicamente della rete (per le utilities) "a huge amount of data from different applications will be generated for further analysis**, control and real-time pricing methods"**

Funzioni di prevenzione e diagnostica "the outages after disasters in existing power structure

Interazione con i clienti finali per ottimizzare le prestazioni e i risparmi anche dei clienti stessi "Demand side management and customer participation for efficient electricity usage are well understood,"

Demand Side Management

Il termine **Demand Side Management si riferisce a scelte generali, su base estesa a livello territoriale o nazionale, il cui scopo è quello di ottimizzare il consumo energetico** dal punto di vista quantitativo e qualitativo.

Servizi proposti dal distributore o dal fornitore di energia, (anche sulla base di incentivi proposti a livello governativo), che motivano il consumatore ad aderire a piani di utilizzo dell'energia che ne ottimizzi la distribuzione durante la giornata, con ripercussioni sia sulla spesa del consumatore, sia sulla richiesta energetica a livello collettivo.

Le funzioni DSM si distinguono fra:

•azioni intese a distribuire in modo regolare la richiesta di potenza nell'arco della giornata, a parità di consumo energetico complessivo **(Demand Response)**

•azioni che mirano a risparmiare in valore assoluto l'energia assorbita a parità di servizio reso.

Demand Side Management - Esempi

- **riduzione della fornitura controllata dal consumatore** sulla base della conoscenza dei consumi in tempo reale;
- Riduzione della fornitura controllata dal consumatore eseguita da un **dispositivo di gestione dei carichi** ;
- **distacco della fornitura controllato dal consumatore** sulla base della conoscenza dei consumi attuali;
- **distacco della fornitura concordato e controllato dal distributore**;
- **scelta dell'orario di uso dell'energia** in base a tariffe multi-orarie;
- **scelta della distribuzione delle fonti**, in caso di sorgenti alternative, **per ottimizzare il consumo e i costi o far fronte a situazioni di emergenza**;
- **gestione dell'energia e dei carichi concordata in un'area più estesa**, comprendente diversi consumatori **in ambito condominiale o di quartiere** e attuata dal consumatore o dal distributore

Classificazione dei sistemi di comunicazione

Two main communications media, i.e., **wired and wireless**, can be used for data transmission between smart meters and electric utilities.

wireless communications have some advantages over wired technologies, such as **low cost infrastructure** and ease of connection to difficult or unreachable areas. However, the nature of the transmission path may cause the signal to attenuate.

… wired solutions do not have interference problems and their functions are not dependent on batteries, as wireless solutions do.

Two types of information infrastructure are needed for information flow in a smart grid system.

The **first flow is from sensor and electrical appliances to smart meters**,

the **second is between smart meters and the utility’s data centers**.

Scelta delle tecnologie e problemi di implementazione

the first data flow **from sensor and electrical appliances to smart meters** can be accomplished through **power line communication or wireless communications**, such as ZigBee, 6LowPAN, Z-wave …

For the second information flow, **between smart meters and the utility's data centers** can be used **cellular technologies or the Internet**.

there are key limiting factors that should be taken into account in the **smart metering deployment process**,

•time of deployment,

•operational costs,

•availability of the technology

•environment type: **rural/urban** or **indoor/outdoor**, etc.

The technology choice that fits one environment may not be suitable for the other.

Tecnologie di comunicazione per Smart Grid

(supporto fisico e infrastruttura)

Table I

SMART GRID COMMUNICATIONS TECHNOLOGIES

Technology	Spectrum	Data Rate	Coverage Range	Applications	Limitations
GSM	900 - 1800 MHz	Up to 14.4 Kpbs	1-10 km	AMI, Demand Response, HAN	Low date rates
GPRS	900 - 1800 MHz	Up to 170 kbps	1-10 km	AMI, Demand Response, HAN	Low data rates
3G	1.92-1.98 GHz 2.11-2.17 GHz (licensed)	384 Kbps-2 Mbps	1-10 km	AMI, Demand Response, HAN	Costly spectrum fees
WiMAX	2.5 GHz, 3.5 GHz, 5.8 GHz	Up to 75 Mbps	10-50 km (LOS) 1-5 km (NLOS)	AMI, Demand Response	Not widespread
PLC	1-30 MHz	2-3 Mbps	1-3 km	AMI, Fraud Detection	Harsh, noisy channel environment
ZigBee	2.4 GHz- 868 - 915 MHz	250 Kbps	30-50 m	AMI, HAN	Low data rate, short range

Requisiti dei sistemi di comunicazione

A. Security

Secure information storage and transportation are extremely vital for power utilities, especially for billing purposes and grid control .

To avoid cyber-attacks, efficient security mechanisms should be developed and standardization efforts regarding the security of the power grid should be made.

Requisiti dei sistemi di comunicazione

B. System Reliability, Robustness and Availability

… Aging power infrastructure and increasing energy consumption and peak demand are some of the **reasons that create unreliability issues** for the power grid.

Harnessing the modern and securecommunication protocols, the communication and information technologies, faster and more robust control devices, embedded intelligent devices (IEDs) for the entire grid from substation and feeder to customer resources, will significantly **strengthen the system reliability and robustness.**

The **availability is based on communication technology**. Wireless technologies with constrained bandwidth and security and reduced installation costs can be a good choice for large-scale smart grid deployments. On the other hand, wired technologies with increased capacity, reliability and security can be costly.

To provide system reliability, robustness and availability at the same time with appropriate installation costs, **a hybrid communication technology mixed with wired and wireless** solutions can be used.

Requisiti dei sistemi di comunicazione

C. Scalability

A smart grid should be scalable enough to facilitate the operation of the power grid .

Many smart meters, smart sensor nodes, smart data collectors, and renewable energy resources **are joining the communications network**.

Hence, smart grid should handle the scalability with the integration of **advanced web services**, reliable protocols with advanced functionalities, such as **self-configuration**, security aspects.

Requisiti dei sistemi di comunicazione

D. Quality of Service (QoS)

In the field of telephony, quality of service was defined by the ITU in 1994.[1] Quality of service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness levels, and so on. A subset of telephony QoS is grade of service (GoS) requirements, which comprises aspects of a connection relating to capacity and coverage of a network, for example guaranteed maximum blocking probability and outage probability.[2]

In the field of computer networking, the traffic engineering term refers to **resource reservation control mechanisms** rather than the achieved service quality. Quality of service **is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow**. For example, a required bit rate, delay, jitter, packet dropping probability and/or bit error rate may be guaranteed. sufficient for the expected peak traffic load. The resulting absence of network congestion eliminates the need for QoS mechanisms.

Requisiti dei sistemi di comunicazione

Quality of service guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over IP, online games and IP-TV, since these often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource, for example in cellular data communication.

A network or protocol that supports QoS may **agree on a traffic contract with the application software** and reserve capacity in the network nodes, for example during a session establishment phase. During the session it may monitor the achieved level of performance, for example the data rate and delay, and dynamically control scheduling priorities in the network nodes. It may release the reserved capacity during a tear down phase.

A best-effort network or service **does not support quality of service.** An alternative to complex QoS control mechanisms is to provide high quality communication over a best-effort network by over-provisioning the capacity so that it is sufficient for the expected peak traffic load. The resulting absence of network congestion eliminates the need for QoS mechanisms.

Definizione di QoS per la Smart Grid

•How to define the **QoS** requirement **in the context of smart grid**.

The detailed mechanism of power price, based on the dynamics of the load, must be investigated. Then, a reward system is built for the home appliance based on the power price and the utility function of the appliance, thus obtaining the impact of delay and outage on the reward of the home appliance. Finally, the QoS requirement is derived by optimizing the reward [27].

•How to ensure the QoS requirement from the **home appliance** in the communications network.

To answer this question, routing methodologies meeting the derived QoS requirement are focused on. Due to the requirements of high computing and storage capabilities imposed by the heterogeneity of the

smart grid, multiple QoS-aware routing within multiple (more than 2) constraints must be considered (for example a greedy algoritm with K-approximation, where K is the number of constraints) [27].

A QoS requirement usually includes specifications, like average delay, jitter and connection outage probability. To derive the QoS requirement, it is important to describe the probabilistic dynamics of the power system, to evaluate the impact of different QoS specifications on the smart grid system and to derive the QoS requirement from the corresponding impact.

Standard per la Smart Grid

There are many applications, techniques and technological solutions for smart grid system that have been developed or are still in the development phase.

However, the key challenge is that the overall smart grid system is lacking widely accepted standards and this situation prevents the integration of advanced applications, smart meters, smart devices and renewable energy sources and limits the **interoperability** between them.

The adoption of **interoperability standards for the overall system** is a critical prerequisite for making the smart grid system a reality.

Standard per la Smart Grid

Seamless interoperability, robust information security, increased safety of new products and systems, compact set of protocols and communication exchange are some of the objectives that can be achieved with smart grid standardization efforts.

There are many regional and national attempts towards achieving this goal:

the **European Union Technology Platform** organization's strategic energy technology plan is all about the development of a smart electricity system over the next 30 years;

the **CEN, CENELEC and ETSI** has formed a Joint working group for smart grid standardization efforts and aim to achieve the European Commission's policy objectives regarding the smart grid. Their efforts focus on **smart metering functionalities and communication interfaces for electric, water and heat sectors in Europe**.