



(51) International Patent Classification:
G05B 15/02 (2006.01)

(21) International Application Number: PCT/US2012/033789

(22) **International Filing Date:** 16 April 2012 (16.04.2012)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) Priority Data:
61/476,083 15 April 2011 (15.04.2011) US

(71) **Applicant** (for all designated States except US): **POWER TAGGING TECHNOLOGIES, INC.** [US/US]; 5425 Airport Boulevard, Boulder, Colorado 80301 (US).

(72) Inventors; and

(75) **Inventors/Applicants (for US only):** **BERNHEIM, Henrik, F.** [US/US]; 7777 East 1st Place #109, Denver, Colorado 80230 (US). **HANSELL, Jerritt, H.** [US/US]; 4625 Pitkin Drive, Boulder, Colorado 80303 (US).

(74) **Agent: CROWSON, Celine Jimenez;** Hogan Lovells US LLP, 555 13th Street, N.W., Washington, DC 20004 (US).

(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD,
SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

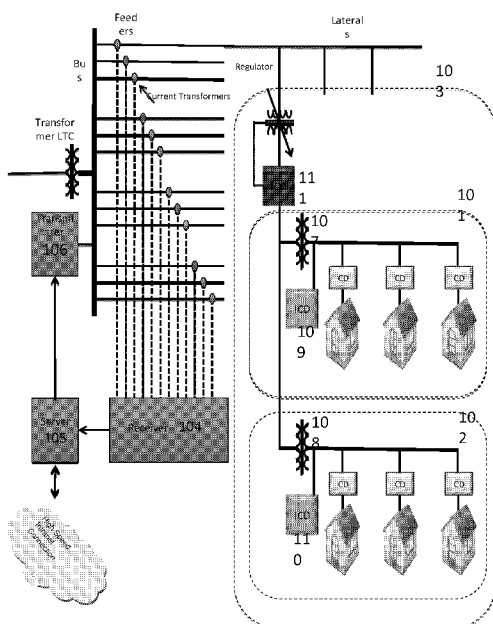
Published:

— with international search report (Art. 21(3))

- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: SYSTEM AND METHOD FOR SINGLE AND MULTI ZONAL OPTIMIZATION OF UTILITY SERVICES DELIVERY AND UTILIZATION

Figure 1.



(57) Abstract: The present invention is directed to utility service delivery wherein distributed intelligence and networking is used in the optimization of the service delivery. The present invention employs a network of data collection nodes and aggregation nodes located on a power grid controlled by a controlling agency. The data collection nodes comprise Intelligent Communicating Devices (ICDs) and Communicating Devices (CDs), which transmit metrics they collect over the power grid from locations near meters or service transformers to the aggregation nodes. Commands, policies, and program updates may be transmitted from a server at an aggregation node to the ICDs and CDs. The ICDs are also capable of issuing control commands to the CDs and grid management devices, acting locally and/or in conjunction with other ICDs, CDs, aggregation nodes, and central controlling agencies. Through these communications and commands, utility services delivery and utilization is optimized.

SYSTEM AND METHOD FOR SINGLE AND MULTI ZONAL OPTIMIZATION OF UTILITY SERVICES DELIVERY AND UTILIZATION

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 61/476,083, filed April 15, 2011, which is incorporated herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention is directed generally toward utility service delivery and the use of distributed intelligence and networking in the optimization of utility, especially electrical, service delivery. Applications in this field are popularly characterized as “Smart Grid” applications.

2. Background of the Invention

The electrical grid in the United States and most other areas of the world is historically divided into two networks: the transmission grid, and the distribution grid. The transmission grid originates at a generation point, such as a coal-burning or atomic power plant, or a hydroelectric generator at a dam. DC power is generated, converted to high-voltage AC, and transmitted to distribution points, called distribution substations, via a highly controlled and regulated, redundant, and thoroughly instrumented high-voltage network which has at its edge a collection of distribution substations. Over the last century, as the use of electrical power became more ubiquitous and more essential, and as a complex market in the trading and sharing of electrical power emerged, the technology of the transmission grid largely kept pace with the technological requirements of the market.

The second network, the distribution grid, is the portion of the electrical grid which originates at the distribution substations and has at its edge a collection of residential, commercial, and industrial consumers of energy. In contrast to the transmission grid, the technology of the distribution grid has remained relatively static since the mid-1930s until very recent years. Today, as concern grows over the environmental effects of fossil fuel usage and the depletion of non-renewable energy sources, electrical distribution technology is increasingly focused on optimization of the distribution grid. The goals of this

optimization are energy conservation, resource conservation, cost containment, and continuity of service.

To optimize electrical service delivery, the operators of the network must be able to quantify and anticipate the demand for power that the distribution grid is expected to provide. To achieve the goals of conservation, cost containment, and continuity of service, it is also necessary to be able to manage and sometimes curtail that demand.

Historically, utilities acquired information about household and commercial usage only when meters were read. Thus, load profiles were based on historical data year to year and on trend analysis as the characteristics of the loads changed. Because of this paucity of information, the utilities have been forced to over-deliver service, so that, for example, a standard outlet or socket in a consumer residence might deliver 122V AC when the loading devices used there are designed and rated to operate at as low as 110 V AC. This disparity provides a substantial opportunity for conservation, but the opportunity cannot be realized without better information about the pattern of demand.

The earliest attempts at conservation voltage reduction were made at the substation level, using instrumentation at the substation and a load-tap changer on the substation transformer. This coarse-grained method is effective for keeping voltages at the load points within specifications, but, to keep some end points from being under-served, requires a safety margin to be employed that results in most end points being slightly over-served, as described above. Finer-grained information is necessary to achieve substantial improvements in conservation.

One well-known experiment in the prior art of conservation voltage reduction involved attaching individual voltage regulators to private residences at the metered point. This model provides significant immediate benefits to individual residential accounts, but utilities must wait for historical data to realize gains such as reduced use of “peaker” plants and avoiding purchasing energy on the spot market. Utilities require finer-grained load pattern data in near-real-time to achieve such gains during the first year of operation of a CVR program.

One potential source of such fine-grained data is communicating “smart meters” which can report voltages. This approach has been piloted and yielded reductions in power usage up to 3%. Because the effective bandwidth per meter of the typical radio-based AMI mesh network does not permit every meter to report its voltage fluctuations frequently in near-real-time throughout the day, these solutions sample only a limited selection of load

points in real-time. The load projections and data thus obtained can be used to drive demand management applications because the smart meters are capable of two-way communications.

Another approach to the conservation problem has been the use of in-facility displays of real-time energy usage, engaging the consumer in the activity of reducing demand. While these techniques are effective for commercial and industrial consumers with automated facility management systems, efforts to engage residential consumers in actively managing their own consumption have met with limited success. Residential systems for energy management are an application of Home Area Networking (HAN).

SUMMARY OF THE INVENTION

The present invention employs a network of data collection nodes, comprising Communicating Devices (CDs) and Intelligent Communicating Devices (ICDs) which transmit the metrics they collect directly over the power distribution grid from edge locations at meters and/or service transformers to an aggregation node. The aggregation node may be located where the controlling agency for utility service applications resides, such as at a distribution substation. The aggregation nodes consist of a receiver that monitors each phase of one or more feeders at the distribution substation, a computer server that receives and stores transmissions from the ICDs and publishes them on a conventional wide-area network attached to the computer server, and a transmitter controlled by the computer server whereby commands, policies, and program updates may be transmitted from the server to the ICDs and CDs. The Communicating Devices are capable of two-way communication with an ICD sited on the low-voltage side of the service transformer powering the CD. The ICDs can aggregate and cache data collected both locally and from CDs, and execute locally stored programs which cause the collected data to be transmitted using a long-range on-grid protocol to the substation or aggregation nodes. The programs may be stored on a non-transitory computer readable media. The ICDs can also issue control commands to the CDs and to grid management devices co-located with the ICD, such as reclosers, capacitor banks, and voltage regulators. In the present invention, the receiver at the aggregation node can infer schematic and topological information about the ICDs such as the feeder and phase upon which the ICD is sited based on various properties of each ICD's transmissions as detected on one or more of the receiver's inputs. These properties may include signal strength.

The stored programs on the ICDs can carry out control activities for conservation and distribution automation without waiting for orders from a central agency, thus reducing the latency of action as well as the communications load on the network substrate.

Unlike HAN solutions, the optimizations obtained via the methods supported by the present invention are not restricted to upper-end consumers who a) may be less in need of the benefits than other consumers who cannot afford to install home-area networking systems and who b) may therefore be less engaged in energy management than is desirable.

Unlike HAN solutions and local-regulator solutions, the optimizations indicated of the present invention may be applied to aggregations of homes and businesses rather than individual homes and businesses only.

Unlike primarily model-based systems, the present invention provides fine-grained data from all measurement nodes in near-real time rather than relying on a predictive model, whether or not supplemented with a small sample of real-time data points.

Unlike centralized systems, the distributed intelligence in the ICDs provides the ability for applications to react in real-time to transient events such as power surges and sags resulting from external events, load changes, and changes in the distribution grid itself.

Unlike prior art systems based on wireless technologies, the present invention does not require a separate network of wireless towers for transmitters, receivers, collectors, and repeaters to be built between the network edge and the final aggregation point. The system of the present invention works wherever electrical power is available. This provides an advantage over prior systems such as RF and cellular solutions, which tend to work poorly in dense urban areas, places where the electrical infrastructure is under ground, and rural areas where cellular service is unavailable or inadequate and the costs of building RF mesh networks are prohibitively high.

The present invention reduces facilities and operational costs associated with running other smart grid models because the communications substrate (the distribution grid) is owned by the utility and does not require the utility to pay service fees to a wireless service provider.

The present invention improves the accuracy of models and optimizations because it is sensitive to the schematic location of the control points and affected load points, while data collection networks and models based on wireless AMI networks must be chiefly based only on geospatial location and are not sensitive to changes in grid topology such as states of switches and reclosers.

Unlike prior art networks that use cellular wireless as all or part of the data reporting path, backhaul of data does not have to be restricted to off-peak hours.

The present invention, by virtue of being capable of concurrently supporting more real-time reporting and minimizing necessary two-way end-to-end interactions, supports multiple concurrent distribution automation and optimization applications including, but not limited to, conservation voltage reduction, asset protection, demand-side load management, service theft detection, service leakage/loss detection, outage boundary identification, rapid fault isolation, safe recovery management, service quality assurance, predictive failure analysis, restriction of access to service, distributed generation and storage management and optimization, and electric vehicle charging control. Most of these applications may be supported by the same data reports, given that the data can be reported with sufficient frequency and continuity.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a portion of an electrical distribution grid including one substation of four feeders, the substation containing a Server 105, a Transmitter 106, and a Receiver 104. Served by the substation are a collection of nested Optimization Zones 101, 102, and 103, where Zone 103 contains a Voltage Regular attached to an ICD 111 and two Transformer Area Network (TAN) zones 101 and 102. Zone 101 is served by transformer 107 and contains one ICD 109 sited at transformer 107 and a plurality of CDs sited at the residences in the TAN zone 101. Zone 102 is served by transformer 108 and contains one ICD 110 sited at transformer 108 and a plurality of CDs sited at the residences in the TAN zone 102.

Figure 2 shows an Optimization Zone 201 having a Transformer Area Network with an ICD 203 which provides for Electric Vehicle Charge management, protecting the Service Transformer 202 against the possibility of overloading due to random uncontrolled charging events.

Figure 3 shows an Optimization Zone 301 having a Transformer Area Network with an ICD 302 which controls a multiplicity of household appliances with embedded CDs as represented by the refrigerators 303. In this configuration, the independent control exerted by the ICD 302 over the embedded CDs 303 allows the ICD to maintain a consistent load over the TAN by staggering the times at which the CDs permit their appliances to engage in high-consumption activities (e.g. cycling the ice-maker, running dishwashers, self-cleaning

ovens) while ensuring that all appliances operate within their safety and convenience specifications (e.g. refrigerators keep foods at the proper temperature, dishwashing cycle requested by 10pm is completed by 6am the next day).

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed generally toward utility service delivery and the use of distributed intelligence and networking in the optimization of utility service delivery, wherein it is beneficial and necessary to establish zones of optimization based on electrical schematic proximity (versus geospatial proximity) of loads on the electrical grid.

The invention comprises at least one data aggregation point, as shown in Figure 1, said aggregation point comprising at least one server 105, at least one on-grid receiver 104, and an optional transmitter 106, together with at least one optimization zone. An optimization zone contains at least one intelligent communicating device (ICD) (109, 110, and 111). An optimization zone may additionally contain other optimization zones, a collection of one or more communicating devices (CDs) residing on the low-voltage side of the same electrical service transformer wherefrom said ICD derives its power, and one or more control devices. ICDs may be sited on service transformers at the edge of the grid, but also on low-voltage transformers associated with medium-voltage grid equipment such as voltage regulators, switches, and capacitor banks, which low-voltage transformers may be installed for the purpose of powering monitoring and control equipment including but not limited to said ICD. Optimization zones may additionally include generation sources such as solar arrays and windmills which are monitored and/or controlled by means of CDs or ICDs.

A server 105 at an aggregation point is a standard ruggedized computer server comprising one or more CPUs, RAM, a non-volatile solid-state data store whereon reside programs to be executed by the CPU and data, a local-area network connection by means of which the server communicates with the at least one receiver 104, the optional transmitter 106, and an optional internet gateway. The receiver 104 monitors the SCADA lines attached to the medium-voltage distribution lines leaving the substation or other nodes of interest on the distribution grid by means of current transformers clamped onto said SCADA lines or other points of contact. A current transformer must be provided for each phase of each feeder over which said receiver is expected to receive transmissions from

ICDs. Said server executes stored programs which store and forward transmissions from ICDs to client applications on the conventional wide-area network and which additionally may from time to time issue policy changes, control commands, and software updates to the ICDs via said transmitter 106.

The transmitter 106 at an aggregation point may use any of a number of on-grid transmission methods for transmitting from a higher voltage to a lower voltage which are well known in the art, such as audio-frequency ripple control. Said transmitter 106 may also employ an alternative broadcast medium.

An ICD consists of a central processor (CPU), a writable non-volatile storage, volatile random-access memory (RAM), and at least one transmitter subsystem enabling software executing on the CPU to order the long-range transmission of messages over the power grid that can be received by said server 105 via one or more said receiver 104 present on at least one aggregation point. An ICD may optionally contain a separate transceiver subsystem capable of using a local, PLC-type on grid communications protocol such as Prime and G3, which are well known in the art, for two-way communication with CDs located on the low-voltage side of the same transformer which supplies power to said ICD. An ICD may optionally contain a receiver subsystem which may be separate from or combined with the long-range transmission subsystem, capable of receiving transmissions sent either over the grid or via some other medium by a transmitter 106. An ICD may optionally contain inputs from instruments for measuring quantities including but not limited to current, voltage, power factor, temperature, and humidity, and outputs for asserting a signal to a control device such as a switch, such that a software agent executing on the CPU of said ICD may read and store measurements and control said optionally attached devices. Said software agents are stored on said writable non-volatile storage, and may additionally store state information, collected data, and policies on said writable non-volatile storage.

A CD is defined as any device which is a) connected to the electrical power grid at low voltage, and b) contains a transceiver for engaging in two-way communication via a PLC-type local on-grid communications protocol such as G3 or Prime. A CD may contain logic or firmware capable of reading inputs from attached measurement devices and writing commands to controllable devices attached to the CD. CDs are typically embedded in other devices which may include but are not limited to commercial and residential electrical meters, household appliances such as HVAC systems, refrigerators, dish washers, pool

pumps, etc., electrical and hybrid vehicles, and charging stations for electrical and hybrid vehicles.

Applications are comprised of distributed intelligent software agents in the form of software programs stored on the nonvolatile writable stores of said ICDs and executing on the CPUs of said ICDs (109, 110, and 111) sited at critical measurement and control points on the grid. Said agents are capable of collecting measurements from CDs in their TAN and from instruments attached to the ICDs. These agents may follow a policy dictating that the agent transmit the collected data or a summary or derivative thereof over the electrical distribution grid to the server 105, or transmit commands to CDs capable of adjusting demand at individual loads (303) or to control locally-attached devices such as voltage regulators (111) which impact the service for an entire zone or collection of zones, said policies being stored on the nonvolatile writable stores of said ICDs. Server 105 may react to transmissions from any ICD by issuing commands via transmitter 106. Said commands may be broadcast or multicast and may be addressed to a single ICD, a collection of ICDs, or all ICDs reachable from said transmitter 106.

In the present invention, the substation receiver 104 infers schematic information about the transmitting ICDs based on the signal characteristics of the received messages on each of the inputs to the receiver, and enhances said received messages with said inferred information. Said inferred information can subsequently be used by distribution automation client applications for the purpose of identifying changes in grid topology, switch states, zone boundaries, outage locations, and the like.

In one embodiment of the invention, an electrical distribution service area is organized into optimization zones based on the characteristics of the areas served by each schematic sub-tree of a radial distribution grid. Figure 1 illustrates such a schematic sub-tree, comprising an outer zone 103 containing a multiplicity of Transformer Area Network zones (101 and 102). In this embodiment, demand data from the TANs is aggregated at server 105 and transmitted via a conventional wide area network to client applications. Based on an analysis of the aggregated data, distribution optimization equipment, such as capacitor banks, voltage regulators, and switches, may be installed at a plurality of the zones, but it is not a requirement of the invention that any or all zones have optimization devices installed. As illustrated in Figure 1, a voltage regulator may be installed on the lateral serving zone 103. In this embodiment, conservation of electrical power can be achieved by lowering the voltage supplied by the substation to all zones, and using some

combination of capacitor banks and voltage regulators to subsequently adjust the voltage in high-demand or highly variable-demand zones such as zone 103.

In a typical embodiment of the invention, one or more ICDs are deployed for every TAN on the low-voltage side of its service transformer. The ICD may communicate with a multiplicity of CDs powered via said service transformer in the TAN. Communications among the ICDs and CDs typically do not propagate significantly beyond said service transformer. As each ICD is installed on the grid, it transmits a provisioning request on a designated on-grid communication channel which is detected by the receiver 104. The server 105 responds with a provisioning fulfillment message which may be transmitted via transmitter 106 or via a hand-held wireless device carried by the human installer of the ICD. The ICD will re-transmit its provisioning request after a randomized delay if it fails to receive a provisioning fulfillment message within a configurable interval. The fulfillment message contains a plurality of policies enabling resident application agents on the ICD, and for each enabled agent a schedule of time slots when the agent has permission to transmit a data report. In some embodiments of the invention, agents may also transmit asynchronous emergency alerts on the provisioning channel. In other embodiments, multiple channels are dedicated to alerting. In some embodiments, ICDs do not transmit on a schedule but only transmit event-driven alerts. All combinations of scheduled and event-based transmission protocols are within the scope of the present invention.

In the preferred embodiment of the invention, the software and firmware residing on the ICDs, comprising the operating system of the host processors in the ICD, the device drivers for attached instruments and controls, the communications protocol stacks for communicating with locally attached instruments and controls, the communications protocol stacks for communicating with CDs within the TAN, the communications protocol stacks for transmitting and receiving long-range communication over the distribution grid above the TAN, and the software programs implementing the application agents can all be individually and collectively updated over the network. Said updates are broadcast to all ICDs from a central distribution point via the transmitter 106. In the preferred embodiment of the invention, the distribution grid is the communications medium used by transmitter 106. In alternative embodiments the transmitter 106 is permitted to be a wireless network or any alternative network medium that is present. The schematic-awareness aspect of the present invention requires that ICDs must transmit messages on the electrical distribution grid, but transmission on-grid from substation to edge ICDs is not required for schematic

awareness. In one embodiment of the invention, transmitter 106 is absent and updates to the ICDs are made by visiting the device or by means of an alternative network path gated via the local ICD-CD communication channel.

In the preferred embodiment of the invention, the rules, policies, goals, and parameters that govern the behavior of the distributed agents can be updated from a central distribution point via the transmitter 106. Distribution of said rules, policies, goals, and parameters is varied and limited by variations in the transmission scheme in various embodiments of the invention in the same manner as are software and firmware updates.

Figures 2 and 3 illustrate embodiments of the invention where CDs are embedded in devices inside a served residence, business, or other consumer. Said devices may include electrical or hybrid vehicles or the charging stations associated with said vehicles. In such embodiments, the ICD 203 can assess the added load that charging an additional vehicle would have on the associated service transformer. Based on the existing and anticipated load, the ICD can grant permission to charge the vehicle or defer the charging of the vehicle until a later date, or implement more complex charging protocol whereby multiple requesting vehicles are served in a round-robin fashion so as to ensure that all vehicles receive at least a partial charge. Additionally, the ICD can report to the central authorizing agency via the long-range on-grid transmission medium the identity of the requesting vehicle, and can suspend the charging process or alert the consumer if the vehicle is not recognized as having permission to charge in that locale.

Using the same local on-grid communications mechanism, the ICD 302 in Figure 3 can limit the total load at zone 301 by managing the power consumption of appliances with embedded CDs in the residences in the zone, represented by the refrigerators 303.

This description of the preferred embodiments of the invention is for illustration as a reference model and is not exhaustive or limited to the disclosed forms, many modifications and variations being apparent to one of ordinary skill in the art.

We hereby claim:

CLAIMS:

1. A system for the optimization of utility service parameters wherein measurements and actions can be independently and/or collectively performed at a multiplicity of distributed intelligent and/or control points at any level of hierarchy within said system, said system comprising:
at least one aggregation node comprising at least one server and at least one receiver;
and
at least one Optimization Zone containing at least one data collection node, wherein the at least one data collection node comprises at least one Intelligent Communicating Device (ICD) executing at least one application agent, said agent being locally stored on a non-volatile store in the ICD and determining the measurements, transmissions, and actions taken at the ICD.
2. The system according to claim 1, wherein the server at the at least one aggregation node stores the transmissions received from the ICDs at said server, and may subsequently forward them to client applications via a conventional wide-area network.
3. The system according to claim 1, wherein said measurements and/or actions are selected from one or more of the following: voltage, power, current, power factor, temperature, humidity, partial pressure of gasses, asset protection, load management, service rate changes, operational tolerance changes, outage and/or recovery management, device charging, power storage, distributed generation, water consumption, gas consumption, and/or predictive failure analysis.
4. The system according to claim 1, wherein the at least one application agent includes locally stored procedures, and wherein policies and parameters governing said procedures act independently in support of a goal or goals that can be stated by a controlling agency.
5. The system according to claim 4, wherein said locally stored procedures, policies, and/or parameters are configured to be dynamically updated at any point in time.
6. The system according to claim 4, wherein communications between nodes and controlling agency, in any combination of communication topologies, are conducted over a power grid.
7. The system according to claim 6, wherein alternative communication paths are used to augment communications over the grid.

8. The system according to claim 1, wherein the system further comprises at least one data collection node comprising one or more Communicating Devices (CDs) that are capable of measurement and/or control.
9. The system according to claim 8, wherein a collection of one or more CDs combined with one or more ICDs defines an Optimization Zone.
10. The system according to claim 9, wherein there are one or more Optimization Zones.
11. The system according to claim 10, wherein the Optimization Zones are nested and/or aggregated.
12. The system according to claim 9, wherein each Optimization Zone includes generation and/or consumption devices.
13. The system according to claim 4, wherein the operation of said stored procedure(s) is informed by data describing the static and/or dynamic schematic location(s) within said system of any or all the points of measurement, control, generation, and/or consumption.
14. A method for the optimization of utility service parameters wherein measurements and actions can be independently and/or collectively performed at a multiplicity of distributed intelligent and/or control points at any level of hierarchy within a system, said method comprising:
 - providing at least one aggregation node comprising at least one server and at least one receiver;
 - providing at least one Optimization Zone containing at least one data collection node, wherein the at least one data collection node comprises at least one Intelligent Communicating Device (ICD); and
 - executing at least one application agent, said agent being locally stored on a non-volatile store in the ICD and determining the measurements, transmissions, and actions taken at the ICD.
15. The method according to claim 14, wherein said measurements and actions are derived from a set or sets of locally stored procedures in the at least one application agent that are based upon globally and/or locally available information.
16. The method according to claim 14, wherein said measurements and/or action are selected from one or more of the following: voltage, power, current, power factor, temperature, humidity, partial pressure of gasses, asset protection, load management, service rate changes, operational tolerance changes, outage and/or recovery

- management, device charging, power storage, distributed generation, water consumption, gas consumption, and/or predictive failure analysis.
17. The method according to claim 15, wherein the locally stored procedures and policies and parameters governing said procedures act independently in support of a goal or goals that can be stated by a controlling agency.
 18. The method according to claim 15, wherein said locally stored procedures, policies, and/or parameters are configured to be dynamically updated at any point in time.
 19. The method according to claim 17, wherein communications between nodes and controlling agency, in any combination of communication topologies, are conducted over a power grid.
 20. The method according to claim 19, wherein alternative communication paths are used to augment communications over the grid.
 21. The method according to claim 14, further comprising providing at least one data collection node comprising one or more Communicating Devices (CDs) that are capable of measurement and/or control.
 22. The method according to claim 21, wherein a collection of one or more CDs combined with one or more ICDs defines an Optimization Zone.
 23. The method according to claim 22, wherein there are one or more Optimization Zones.
 24. The method according to claim 23, wherein the Optimization Zones are nested and/or aggregated.
 25. The method according to claim 22, wherein each Optimization Zone includes generation and/or consumption devices.
 26. The method according to claim 15, wherein the operation of said stored procedure(s) can be informed by data describing the static and/or dynamic schematic location(s) within said system of any or all the points of measurement, control, generation, and/or consumption.
 27. The method according to claim 14, wherein the application node alters the behavior of at least one application agent by issuing a one-time command or changing a policy.

Figure 1.

1/3

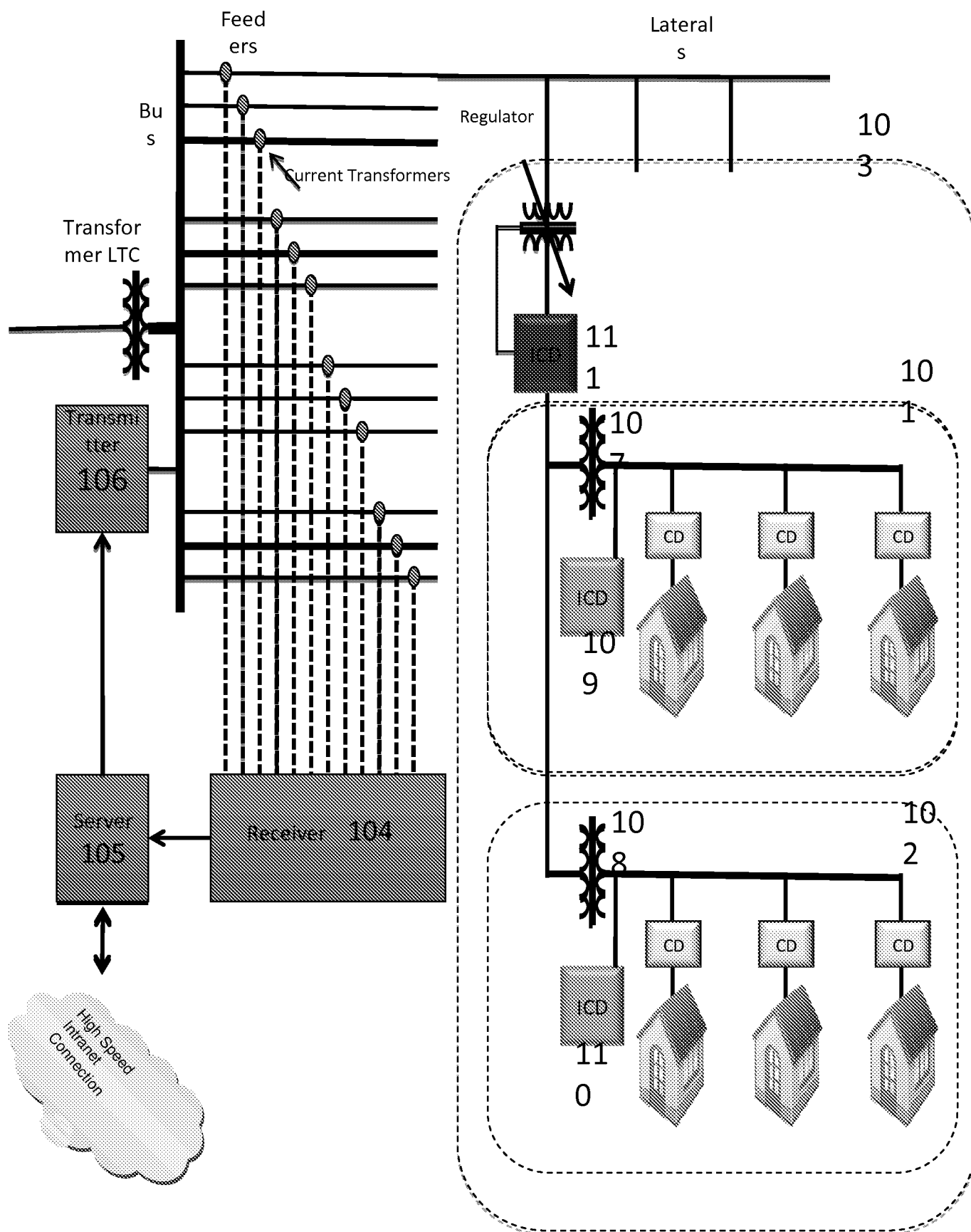


Figure 2.

2/3

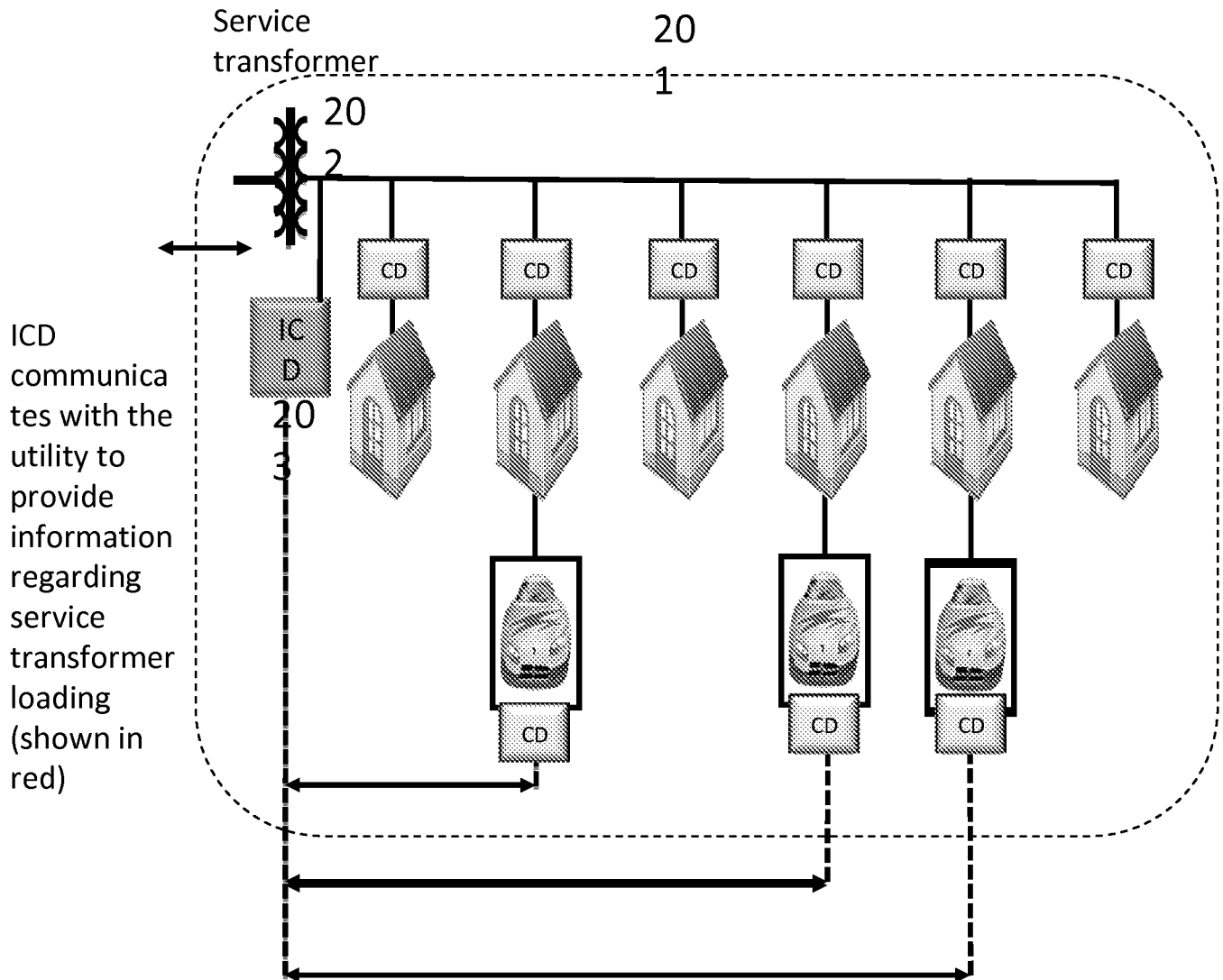


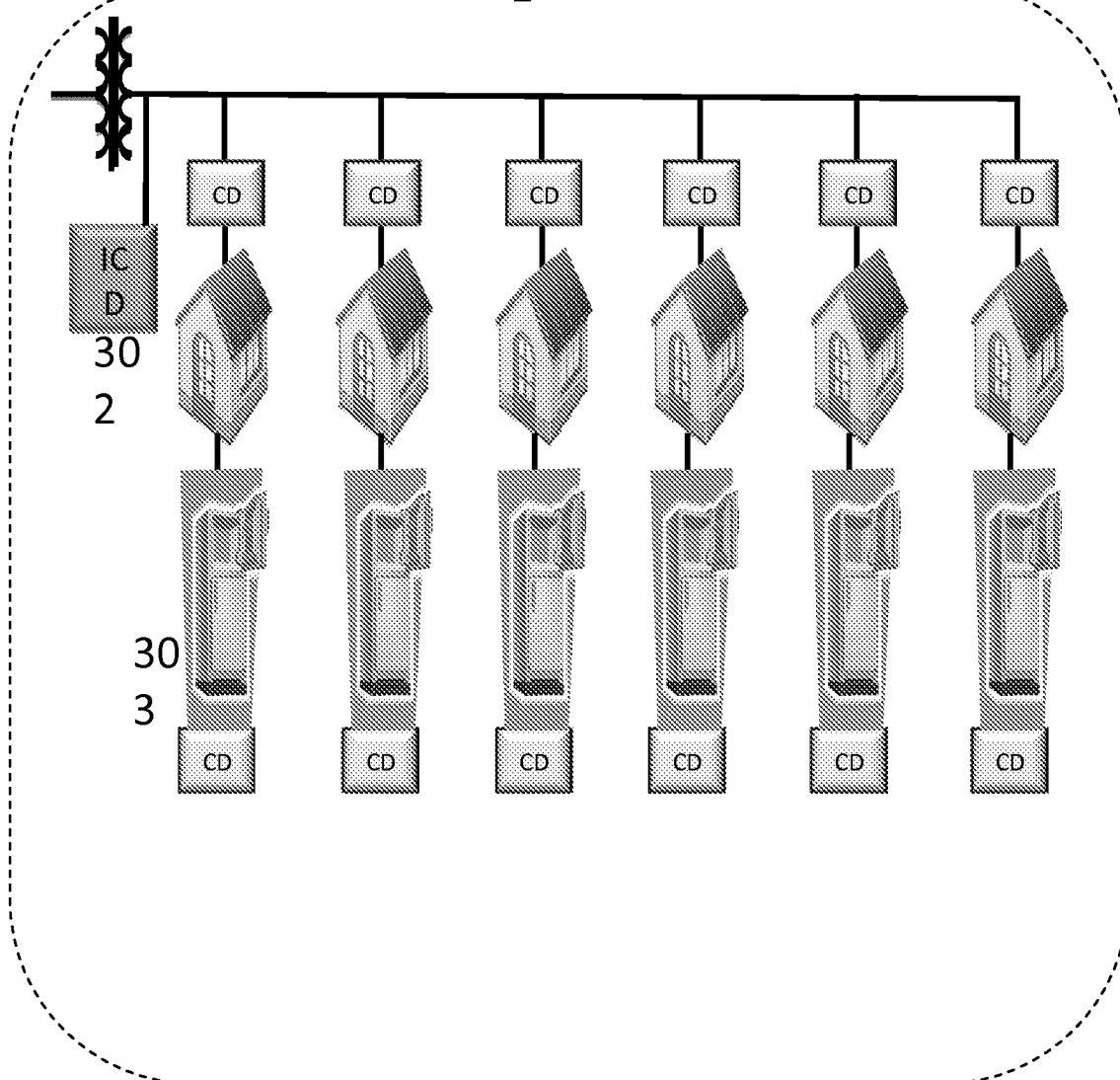
Figure 3.

3/3

Service
transformer_

30

- 1 -



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/033789

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G05B15/02
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G05B H02J H04B G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/262313 A1 (CHAMBERS GREGORY L [US] ET AL) 14 October 2010 (2010-10-14) paragraph [0006] - paragraph [0016] paragraph [0025] - paragraph [0028] paragraph [0033] - paragraph [0065] paragraph [0071] - paragraph [0076] paragraph [0084] - paragraph [0091] -----	1-27
X	US 2009/088907 A1 (LEWIS KARL [US] ET AL) 2 April 2009 (2009-04-02) paragraph [0022] - paragraph [0023] paragraph [0026] - paragraph [0030] paragraph [0033] - paragraph [0036] paragraph [0042] - paragraph [0046] ----- -/ --	1-27



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

30 August 2012

Date of mailing of the international search report

06/09/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Cîrîc, George

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/033789

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/040479 A1 (BRIDGE SETH W [US] ET AL BRIDGES SETH W [US] ET AL) 14 February 2008 (2008-02-14) paragraph [0035] - paragraph [0164] -----	1-27
A	WO 2010/141859 A1 (LEVITON MANUFACTURING CO [US]) 9 December 2010 (2010-12-09) the whole document -----	1-27

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/033789

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010262313 A1	14-10-2010	CA 2758287 A1	14-10-2010
		CN 102460335 A	16-05-2012
		GB 2480796 A	30-11-2011
		US 2010262313 A1	14-10-2010
		WO 2010118332 A1	14-10-2010

US 2009088907 A1	02-04-2009	US 2009088907 A1	02-04-2009
		WO 2009046132 A1	09-04-2009

US 2008040479 A1	14-02-2008	US 2008040479 A1	14-02-2008
		US 2011025556 A1	03-02-2011

WO 2010141859 A1	09-12-2010	CA 2764501 A1	09-12-2010
		CN 102484503 A	30-05-2012
		WO 2010141859 A1	09-12-2010
