Infotility – 3G-System of the Future Legacy Use Cases – Software demonstration of intentional islanding

Version 3.1

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1 Descriptions of Software Demonstration of Intentional Islanding

This work leading to the 3G-System of the Future project performed by Infotility has been funded by the US Department of Energy and cost shared by Infotility, Inc and a utility. The use cases have been developed and have been incorporated into Infotility's GridAgents software platform. Infotility owns all intellectual property for the GridAgents Software. The Use Cases developed by Infotility as requirements for the DOE project titled "3G System of the Future: Advanced Distribution Operation with DER Integration". For this project, Infotility has created 2 legacy use cases from the work performed in this project. The legacy use cases include the following and are based on the same research project:

1. Dispatch of customer load controllers for compact network load alleviation (not described in this document)
2. **Software demonstration of intentional islanding**

1.1 Existing Gridagents™Framework

The GridAgents™ framework is currently under development by Infotility as a platform for building advanced, large-scale distributed energy resource (DER) and distribution network control (DNC) solutions. GridAgents is a novel, advanced software foundation (multi-agent system technology) for developing optimized DER control in varying operational configurations such as Microgrids, demand response automation, DNC, and intelligent monitoring applications. It is designed to integrate with SCADA systems and Internet-enabled applications. The use cases in this document are based on the coordination and interaction of GridAgents within Compact Network configurations.

1.2 Function Name

Software demonstration of "intentional islanding.

1.3 Brief Description

Intentional Islanding and auto-reconfiguration

Islanding refers to the isolation of the compact network. This is done by opening the network protectors upon recognition of a system fault (or the network operator decides to isolate the switch) Once this happens, the compact network must dispatch the local generation equipment and, should the local generation not be sufficient to meet the normal loads of the grid, demand reduction occurs through the customer load controllers. Alternatively, if localized energy storage is available, the storage can provide ride-through capability during the islanding event depending on the economics and timing requirements to re-establish compact network power flows. Figure 1 below shows a physical depiction of a generic situation with loads, network protectors, and agents. Storage devices could be situated within any portion of the network either on the customer- or utility-side of the meter in order to balance power flows and provide for temporary ride-through on the network from grid contingencies.

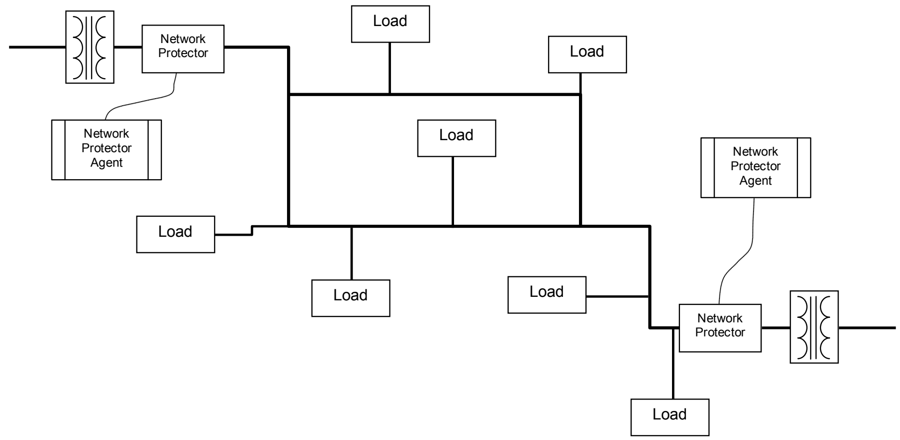

Figure 1 Compact Network Islanding

The following excerpt is taken from a Navigant Consulting report on the point of universal agreement as to the definition of a Microgrid

Points of Universal Agreement

- A Microgrid consists of interconnected distributed energy resources capable of providing sufficient and continuous energy to a significant portion of internal load demand
- A Microgrid possesses independent controls, and intentional islanding takes place with minimal service interruption (seamless transition from grid-parallel to islanded operation)

One key feature of a compact network (or Microgrid) is its ability to separate and isolate itself (islanding) from the utility's distribution system during a grid disturbance, as distributed generation systems typically can today. This is accomplished via intelligent power electronic interfaces and a single, high-speed switch. During a disturbance, the distributed energy resources (DER) and corresponding loads can be separated from the utility's distribution system, isolating the Microgrid's load from the disturbance (and thereby maintaining high-level service) without harming the integrity of the utility's system. Intentional islanding of DER and loads has the potential to provide a higher level of reliability to end users than that provided by the distribution system as a whole. Then, when the utility grid returns to normal, the Microgrid automatically resynchronizes and reconnects itself to the grid, in an equally seamless fashion.

1.4 Narrative – Compact Networks

The use cases in this project concentrated on a small subsection of a major city's power grid called *a compact network* or *Microgrid*. A schematic of a typical compact network is shown in Figure 2 and services 18 to 25 managed customers within an approximate 12 square block area. It is estimated that each Microgrid will serve 10 to 15 megawatts of load. In this figure the boxes labeled **NP** are network protectors that can be used to shut off load through the associated transformer. The boxes labeled **LC** are load controllers used to shed load with the associated meter **M**. Generators **G** can be used to provide power to and effect VAR management within the compact network. The sensors denoted by the circles labeled **S** represent arrays both monitoring and control devices and have the functions as stated on the schematic labels.

The potential advantages of this design are as follows:

- It reduces the amount of low voltage secondary cable and the corresponding operations and maintenance costs.
- The network protectors at each transformer enable islanding via load response at the Microgrid level.
- Careful monitoring of the transformer and associated vault voltages can reduce the exposure of the public to stray voltage
- The design frees existing underground conduit space for other uses such as telecommunications
- The Microgrid provides a test bed for deployment and testing of sensors and associated control processes.

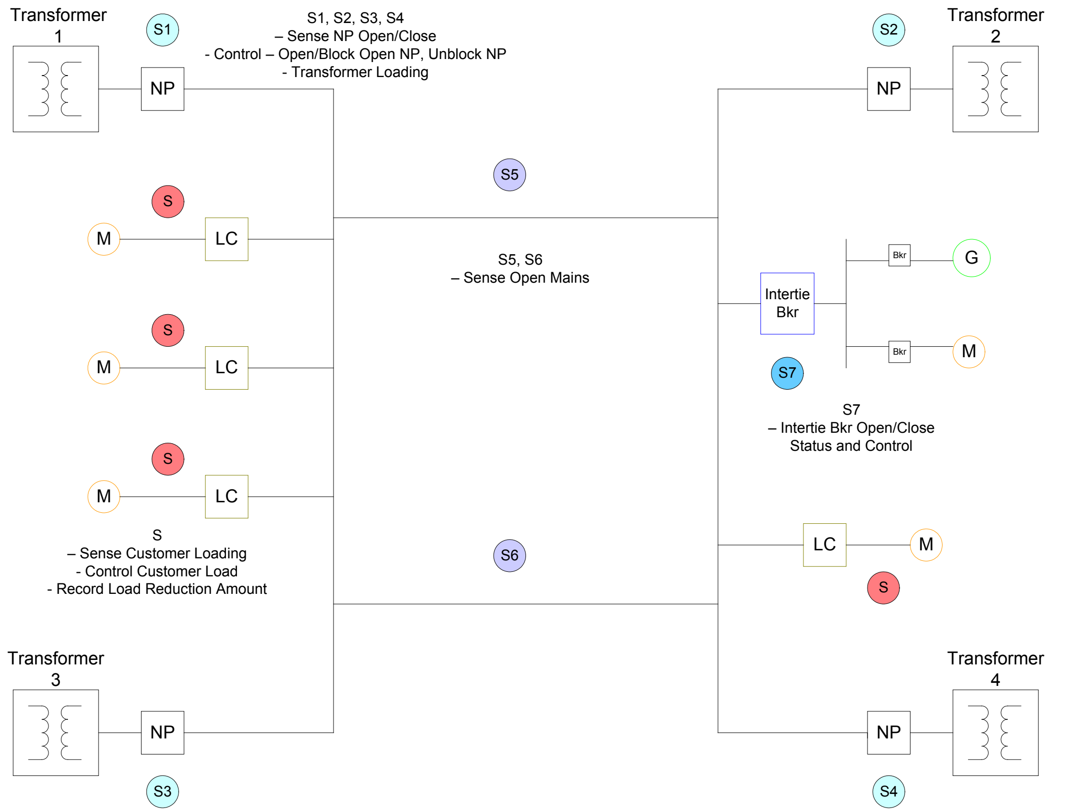

Figure 2 Potential compact network demonstration – generic configuration (Copyright: Infotility)

1.5 Actor (Stakeholder) Roles

Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
Facility Operator	Person	Manages the energy for a facility
DR Asset	Demand Response Asset, device	An energy resource that is capable of reducing load in response to Demand Response Events, Electricity Price Signals or other system events. E.g. building EMS, loads connected to relays, lighting dimming, etc. Also referred to as **LC** in the Infotility compact network diagram in Figure 1.
DER Asset	Distributed Energy Resource (DER) Asset; device	Distributed energy resources are small, modular, energy generation and storage technologies that provide electric capacity or energy where it is needed* A DER may be implemented by an Electricity Consumer to generate electricity for its own use during DR Events in order to meet load-shedding obligations it may have within a Demand Response Program. *Definition of DER provided by the Department of Energy, http://www1.eere.energy.gov/femp/pdfs/31570.pdf This use case assumes that the DER systems are a combination of inverter-based DG and machine-based DG. In this case, energy storage systems can be considered to be an inverter-based DG system.
Microgrid Manager Agent	Software Program	Agent representing customer or facility or Compact Network. In this instance, the Customer Manager Agents is a GridAgents software program.
SmartSwitch Agent	Software or combined software and hardware device.	Fast Switching mechanical and or digital relay combined with intelligence and instructions coming from the Compact Network Manager Agent.
DA Asset	Distribution Automation Asset: Device	Distribution system asset such as switches, relays, transformers, ect. Also refers to the **NP** (Network Protector) in Figure 1.
Distribution Automation	System	System Provides real-time data to the system demand modeler and control room operator

Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
System		
Network Protector Agent	Agent	Intelligent agent which models Emulates and provides status information about a main distribution relay usually used to protect transformers
Network Operator	Person	Person responsible for activation of automated load control notification and implementation. Also responsible for determining network status.

1.6 Information Exchanged

Information Object Name	*Information Object Description*
Active Frequency anti-islanding control	Active frequency anti-islanding algorithm(s).
Reactive Power anti-islanding control	Reactive power anti-islanding algorithm(s).
Essential Load ID	Critical loads which are tagged by Microgrid Manager Agent
Non-essential Load ID	Noncritical loads where are tagged by Microgrid Manager Agent
Islanding status	Information on the islanding event such as time of event, frequency or droop characteristics, internal power requirements, etc.

1.7 Activities/Services

Activity/Service Name	*Activities/Services Provided*
DA Asset Agent	Resource Agent. An agent is a software entity that models a resource.
LoadControllerAgent	Emulates and provides cost-of-action information about demand response devices and strategies, e.g., setpoint reset, current limiters, and dispatchable / curtailable loads. Decides on critical and non-critical load status.
Microgrid Manager Agent	Manager agent for making decisions on non-critical loads, islanding control strategies, etc when the Microgrid is in Intentional Islanding operation.

1.8 Contracts/Regulations

Contract/Regulation	*Impact of Contract/Regulation on Function*
Customer contracts with Network Operator	Determines which customers participate in Microgrid Intentional Islanding
Utility operations	FERC and state regulators oversee utility operations

Policy	*From Actor*	*May*	*Shall Not*	*Shall*	*Description (verb)*	*To Actor*
Intentional Island Request	Network Operator	X			Provide notification of intentional islanding event for Macrogrid protection scheme	MicroGrid Manager Agent
Secure data	Everyone		X		Secure information must not be accessible by unauthorized entities and must not be prevented from being accessed by authorized entities	Everyone

Constraint	*Type*	*Description*	*Applies to*
Laws of Physics	Environmental	Laws of physics for power system and building EMS operations	All
Technology	Environmental	Technology constraints for providing notification and compliance data	All
Security	Environmental	Security policies and technologies must be established and used to address all security needs at the appropriate/contracted levels	All

2 Step by Step Analysis of Software Demonstration of Intentional Islanding

2.1 Steps to implement function

2.1.1 Preconditions and Assumptions

Actor/System/Information/Contract	*Preconditions or Assumptions*
System operations	Infrastructure has been put in place to implement automated load control and Intentional Islanding
Distribution operations	Normal power system operations where some customers have contracted with network operations to participate in Intentional Islanding programs and services
Customer Equipment	These customers have Energy Management Systems, load control relays, lighting dimming systems in place that can be directed to be controlled in order to achieve Intentional Islanding program objectives of load shedding, active frequency control and reactive control for both inverter-based and machine-based DG within the Microgrid. In addition, the customer and/or LSE must have installed a fast switch to island the Microgrid. As well some of the DER Assets (DG) must have both voltage and frequency regulation functions

Actor/System/Information/Contract	*Preconditions or Assumptions*
Distribution Automation and SCADA	LSE has installed two-way communication network (AMI, SCADA, Zigbee, etc) which allows real-time monitoring of distribution assets as well as real-time communication of status between system entities (agents or software programs running on computational platforms).

2.1.2 Steps – Software Demonstration of Intentional Islanding

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged
1.1	Network Operator decides to island network;	Network operator; SmartSwitch Agent	Islanding Condition Alert;	Network operator decides to island the Microgrid. This is a pre-planned islanding event. The transition process between grid-parallel and standalone operation is called intentional islanding where the Microgrid must shut down when the main grid is lost and then start back up again to supply local loads. In this case, a disruption or transient effect to the loads within the Microgrid is not acceptable. For these systems, a seamless transition control is needed.	Network Operations; Distribution Automation System,	SmartSwitch Agent; Manager Agent, Control room operator	Alert object
1.2	Microgrid SmartSwitchAgent opens NP causing autonomous intentional islanding situation	Inverters, network protectors (NP)	Islanding Condition Alert;	Automatic switching by Microgrid to smoothly transition between grid-parallel and grid islanded operation. Loss of grid connection is detected first, followed by fast switching and notifications. This case assumes no pre-planned event.	SmartSwitch Agent; Fast Switch; Manager Agent	Manager Agent, Control room operator	Alert object

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged
1.3	Shed Non-critical loads	Microgrid Manager Agent	Islanded load shedding	Not all of the load within the facility can be served when the Microgrid trips to islanded operation. Some of the loads within the Microgrid can be disconnected to allow for secure operation of critical load. The Microgrid Manager Agent is able to differentiate between critical and noncritical loads. The Microgrid Manager Agent will send all non-essential loads a non-essential load ID tag to the load controllers resulting in immediate disconnect.	Microgrid Manager Agent	Load Controllers	Non-critical load shed schedule
1.4	DER Asset Control Algorithm	DER Asset Agent	Islanding Control Strategy for DER	Algorithm to implement active frequency anti-islanding control for inverter-based DG and reactive power anti-islanding control for machine-based DG (DER Assets) . This means at least some of the DG must have both voltage and frequency regulation functions	DER Assets; DER Asset Agent; EPS	DER Assets (Inverter-based and Machine-based DG)	Control Plan
1.5	Transient Voltage Ride Through Control	Energy Storage Device (UPS)	Transient Voltage Control	Loads subject to transient voltage disturbances (e.g., data centers) will still need an uninterruptible power supply device to ride grid disturbances. Not all Microgrid configurations will have energy storage, but in the case that it exists, the UPS will provide for fast recovery of the Microgrid being islanded	Microgrid Manager Agent	UPS	Transient Voltage Control Algorithm/Plan
1.6				Add resynchronization (and in the assumptions)			

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged
1.6	Voltage and Frequency Regulation	Microgrid System	Voltage and Frequency Regulation	In order to prevent the large voltage and frequency transients that follow the loss of the Macrogrid, the intentional islanding must maintain voltage and frequency regulation while exhibiting fast transient disturbance rejection qualities. The Microgrid control policy must control the very large transient currents on its DER Assets.	SCADA, Distribution Automation System, Microgrid power system state	Microgrid System	Voltage and Frequency Regulation Stabilization Control

2.1.3 Post-conditions and Significant Results

Actor/Activity	*Post-conditions Description and Results*
Manager Agent	Manager Agent notifies all parties of Intentional and Unintentional islanding statistics (duration, frequency and reactive power characteristics, DER Asset schedules, UPS schedules, and non-critical load shedding schedules during the islanding event.

3 Auxiliary Issues

3.1 References and contacts

ID	Title or contact	Reference or contact information
[1]	Infotility	David Cohen

3.2 Revision History

No	**Date**	**Author**	**Description**
3.1	June 10^{th}, 2010	David Cohen	Finalize Use Case