**Networked Redistribution Grid**

**(NRG)**

**cs337 Software Engineering**

**Software Requirements Document (SRD), Software Design Document (SDD) and Software Test Plan (STP)**

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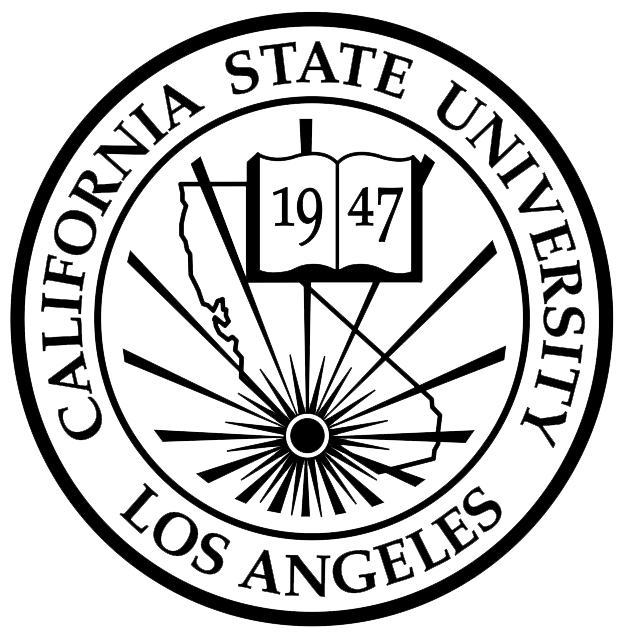
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Jose Macias Date

**Document Change Log**

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# List of TBD Items

|  |  |  |  |
| --- | --- | --- | --- |
| Page | **Item** | **Description** | **Status** |
| Section 4 | Detailed design | TBC during cs437 | Will not be completed this quarter |
| Section 5 | Implementation | TBC during cs437 | Will not be completed this quarter |
| Section 6 | Test Plan | TBC during cs437 | Will not be completed this quarter |

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**1. INTRODUCTION**

**1.1 Purpose**

The purpose of this document is **four-fold**:

a) Completely define a full set of requirements for the **NRG** – **Section 3.0**.

(These sections correspond to a Software Requirements Document SRD).

b) Completely define the design for the **NRG – Section 4.0**.

(These sections correspond to a Software Design Document, SDD).

c) Define and (partially) implement feasible modules for the **NRG – Section 5.0**.

(These sections correspond to the Software Implementation Document, SID).

d) Completely define the Test Plan for the **NRG – Section 6.0**.

(These sections correspond to a Software Test Plan, STP).

The complete definition of all NRGrequirements provides the source requirement inputs for the development of the subsequent supporting software subsystems documents.

**1.2 Scope**

The documentation developed as part of this cs337 class includes the NRG SRD and the SDD (Sections 1 through 4). The remaining parts of the document (Sections 5 and 6) are left for the next software engineering class, cs437.

The scope of this document includes the following:

* All functional and non-functional requirements on the **NRG** are captured. This includes Verification & Validation (V&V) requirements, as well as inter-software subsystems requirements.
* A complete set of **NRG** Requirements, derived and traceable to the incoming cs437 class requirements. These requirements are organized by key **NRG** functional units shown on the Level 1 DFD. The Level 1 DFD is shown on page [i-8].
* A trace matrix, relating all **NRG** functional requirements to functional subunits as expanded in lower level DFDs. Level 2 and 3 DFDs are provided on pages [TBD].
* The functional requirements defined in the **NRG** Requirements section have been expanded to include more specific hardware requirements.

**1.2.1 Document Organization**

The organization of this document provides a natural 'flow' or allocation of requirements to each succeeding section.

Details regarding the overall document are given in sub-section 1.5 below.

**1.2.2 Relationship to Other Documents**

The **NRG** SRD/SDD/STP/SID is a complete self contained document. Some relationships to other documents in the literature are indicated below in sub-section 1.5.

**1.3 NRG Architecture**

1.3.1 Detailed Context Diagram (DFD Level 0)

The **NRG** architecture is summarized in the Context Diagram (DFD Level 0) given below. A more complete Functional Description is given in Section 2 of this document.

Predictive Function

Response Function

Data Management Function

Control Interface Function

User Interface Function

NRG

Grid Data

Weather Data

Device Data

Interface Input IIIinput

Device Instructions

Interface Output

NRG DFD Level 0 Diagram

**1.3.2** Description and major functions of the **NRG**

***The primary objective of NRG is to provide a system by which the daily tide of energy usage can be moderated to reduce dependence on inefficient power plants. The system aims to do this by anticipating demand and reducing the power used by devices that are non-essential for the uninterrupted flow of daily life. This would in turn reduce overall power generation costs and environmental stress.***

The NRG software system shall:

- Predict future grid usage based on historical data.

- Adjust power usage for non-essential devices.

- Maintain a database of relevant historical data.

- Provide device data to their owners.

- Allow a technician to take control of the system in an emergency.

The NRG system differs from other smart grid plans by taking a more active role in reducing power usage during peak hours. In other systems, the force behind any change in energy usage is ultimately the end user. This reliance on individual participation means that in order to see a significant result, a large number of people need to change their habits. This is unlikely. NRG avoids this by adjusting consumption rates automatically when needed without any input from the consumer.

***The next level description will be given in Chapter 2.***

**1.5 Documentation Development Process**

The **NRG** detailed functional description is documented in section 2.0. Basically, Section 2 is a succinct software description for the document. The overall detailed functional description is based on higher level DFDs (above level 1). All major functional units are described in detail in this part of the document.

In general, all requirements affecting **NRG** are captured in Section 3.0. These requirements are a refinement and completion of requirements first collected as part of a Software Engineering project. The document is cited in Section 1.2.2. This section is the one worked in most detail to become a reasonably complete Software Requirements Document (SRD). It includes both functional and non-functional software requirements together with several detailed “rational” paragraphs whenever necessary to complete the understanding of each requirement.

Section 4 is the **NRG** detailed Design Description Document (SDD). This part of the document includes all higher level DFDs as described in section 2 plus all interface units. The document is highly technical and it is based on section 2 descriptions.

Section 5 includes elements of implementation of **NRG**. This section includes the various constraints that effectively limit the implementation as well as the sub-units that will be coded. The implementation goals are defined and the code and pseudo code are included as an attachment to this section.

Section 6 is the last major section in this document and includes the overall Test Plan (TP) of the **NRG**. The test plan details the various techniques used to test the requirements and it also includes a Validation Matrix where each requirement specified in section 3 is listed with its corresponding validation method. In addition, TP specifies the mandated peer reviews needed to validate the stakeholders part of the requirements.

**1.6 References**

All references used in the creation of this document are listed below.

[http://smartgridcc.org/wp-content/uploads/2012/08/000000000001021126.pdf](http://smartgridcc.org/wp-content/uploads/2012/08/000000000001021126.pdf#_blank)

[http://www.ccst.us/publications/2011/2011smart-final.pdf](http://www.ccst.us/publications/2011/2011smart-final.pdf#_blank)

[http://www.youtube.com/watch?v=QqfMwEQ2pbc](http://www.youtube.com/watch?v=QqfMwEQ2pbc#_blank)

**1.6.1 Controlling Documents**

There is no document controlling this document.

**1.6.2 Applicable Documents**

Macias, Jose *aaFRD cs337 Draft.doc* “Our requirements template”

**1.6.3 Standards**

No Standard has been used in the creation of this document. However, some Standards described in textbooks have been examined as a reference. In particular, the IEEE standard has been briefly discussed in class.

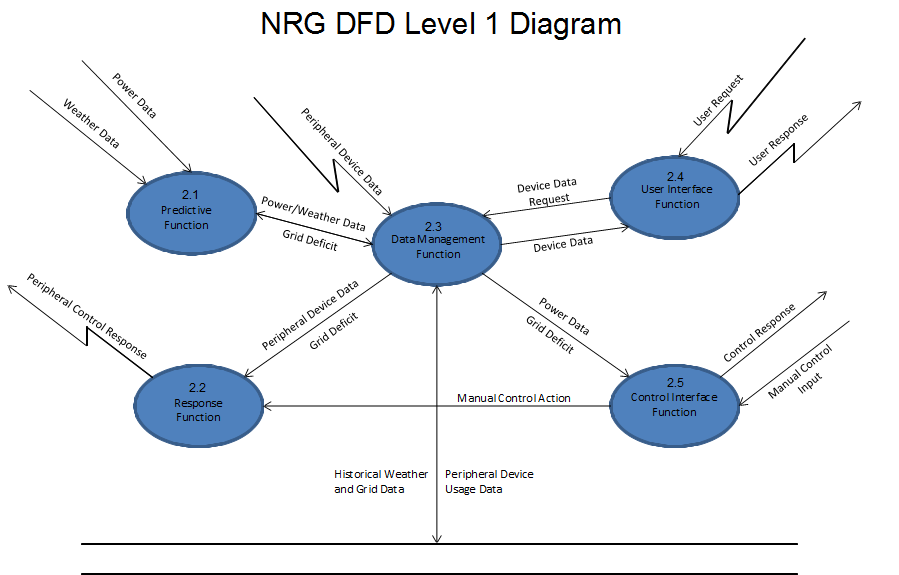
**2.0 DETAILED FUNCTIONAL DESCRIPTION OF THE *NRG***

2.1 Detailed **NRG** Functional Description.

The major tool used to design **NRG** is the Data Flow Diagram, DFD. The rational behind the selection of DFDs as the preferred design tool, was their simplicity and versatility. In the future more sophisticated tools may be used particularly if a correlation from Design to Requirement to Implementation and Testing is found to be a necessary addition.

2.1.1 Higher Level Data Flow Diagrams.

The **NRG** major functional design components are shown in the DFDs below.



2.1.2 Detailed Description of **NRG** Major Sub-Units

The **NRG** major functional subunits shown in the DFDs in the previous sub-section, are described in detail below.

2.0 Predictive function

* PF takes in a collection of data from two external sources. The two external sources are power data and weather data.
* Power data are information about power usage demand from power plant. PF processes power data to find peak demand time from power plant that could cause stress on the power grid and create data on predicted grid deficit.
* Weather data are current real-time data on weather forecast that affect the demand on power usage.
* PF will take in weather data to adjust the predicted grid deficit to account for change in weather. During hot weather climate, the demand on the power grid can exponentially increase.
* PF calculates the information from the two external sources and generates the final prediction on grid deficit to be used in.

2.1 User Interface Function

* The UIF allows the owners of NRG compliant devices to view data on their device's energy usage.
* This data will contain data on how much energy the device consumes, how often it is placed in a reduced power state, estimates on the device's efficiency compared to factory specifications. Energy information will be converted into a monetary value to avoid confusion over unknown units of energy (Joules, BTUs, etc.).
* This function enhances the transparency of the system by providing all device data collected and stored to the owners of NRG compliant devices along with information on how frequently the system alters their device's performance.

2.2 Data Management Function

* The DMF will control all database interaction within the system.
* It will access and maintain tables containing historical weather data, power production data, grid deficit data, current peripheral device usage data, and individual device historical data.
* This centralized access point allows all database queries to be managed in one place and simplifies the task of data storage and retrieval.
* Additionally, this reduces the likelihood of concurrent queries that could result in errors.

2.3 Control Interface Function

* The CIF is a built in redundancy layer to allow direct human control over the system in case of errors or emergencies.
* Any system of this scope needs multiple safety systems.
* The ability of the PF and RF to accurately assess the supply and demand of power to the grid is necessarily limited by the ability of engineers to anticipate every possible situation and its consequences.
* Thus, by including a CIF, any extraordinary circumstances can be interpreted and responded to by person.

2.4 Response function

* Peripheral device's power consumption will be controlled by the RF.
* It does so, when the RF receives the device and grid deficit data from the DMF.
* Also, to help get a fast emergency response, it will be in constant communication with the CIF. Once the data is received, it will analyze it and rank non-essential appliances in order of importance. For example, non-essential appliances like driers, chargers, etc.
* If more power needs to be limited, RF will now adjust its ranking and prioritize based on the data it received. For example, if the weather is hot, a water heater will be now the first to be limited of power consumption.
* Vice versa, in cold weather, air conditioners will be first to be limited.
* Once this process is complete, response function will send a signal wirelessly to the peripheral device's chip and lower its power consumption as needed.
* It will automatically turn off power consumption of these devices when CIF asks to.

**3.0 *NRG* REQUIREMENTS**

3.1 NRG Functional Requirements

This Section collects all **NRG** Functional Requirements. The Section includes the complete set of functional requirements with explanation and rational where the statement of the requirement was deemed insufficient or needing additional background/justification. All requirements relate to the design modules described in Section 2. An effort has been made to standardize the correlation between the design modules and the requirements to make their access and organization more consistent. For example, module 2.1 requirements are labeled 3.1, sub-module 2.1.1 requirements are labeled 3.1.1 and so on. The list of requirements follows.

|  |  |
| --- | --- |
| Requirements Related to Module 2.1: Predictive Function | |
| Requirement No. | Requirement Description |
| 3.1-1 | * NRG shall receive data on present grid demand and current weather conditions. |
| 3.1-2 | * NRG shall receive historical data on past weather and grid demand. |
| 3.1-3 | * NRG shall estimate grid deficits based on historical data and present conditions. |
| 3.1-4 | * NRG shall monitor current grid supply levels. |
| 3.1-5 | * PF shall overestimate demand by 1% to maintain a small supply buffer. |
| 3.1-6 | * The PF shall estimate grid and weather data if current data is unavailable. |

|  |  |
| --- | --- |
| Requirements Related to Module 2.2: User Interface Function | |
| Requirement No. | Requirement Description |
| 3.2-1 | * NRG shall receive requests for data from peripheral device owners. |
| 3.2-2 | * The UIF shall send device data to the user that requested it. |
| 3.2-3 | * NRG shall authenticate users for data requests to ensure privacy. |
| 3.2-4 | * NRG shall present user data in a way that is easy for the layman to understand. |
| 3.2-5 | * NRG shall provide data on both current usage and historical usage for device owners. |

|  |  |
| --- | --- |
| Requirements Related to Module 2.3: Data Management Function | |
| Requirement No. | Requirement Description |
| 3.3-1 | * NRG shall accept usage data from peripheral device chips. |
| 3.3-2 | * NRG shall have a database containing historical weather, grid supply, grid demand, and deficit prediction data. |
| 3.3-3 | * The database shall be continuously updated with new weather and grid data as it is received. |
| 3.3-4 | * .The database shall contain historical data on individual devices on the grid. |
| 3.3-5 | * The DMF shall receive queries for user data from the UIF, then returns historical device usage statistics for the given device. |

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|  |  |
| --- | --- |
| Requirements Related to Module 2.4: Control Interface Function | |
| Requirement No. | Requirement Description |
| 3.4-1 | * NRG shall provide an interface for a technician to assert direct control over the system. |
| 3.4-2 | * NRG shall present current grid data to the technician through the interface. |
| 3.4-3 | * The manual control interface shall not be accessible via the internet. |
| 3.4-4 | * The interface shall allow technicians to set specific time frames for manual actions. |
| 3.4-5 | * The default time frame shall be no more than 24 hours. |
| 3.4-6 | * CF shall provide a means for a technician to send instructions to the RF according by device type and priority. |
| 3.4-7 | * CF shall request information from the DMF |
| 3.4-8 | * CF shall display real time graphical representations of weather and grid data |
| 3.4-9 | * CF shall send and receive device instructions |
| 3.4-10 | * CF shall provide a means to cut all power to NRG compliant devices |
| 3.4-11 | * CF shall manually set a power limit for each priority group |
| 3.4-12 | * CF shall allow a technician to remove all previous instruction sets |
| 3.4-13 | * CF shall send an instruction set that automatically suspends the RF |

|  |  |
| --- | --- |
| Requirements Related to Module 2.5:  Response Function | |
| Requirement No. | Requirement Description |
| 3.5-1 | * NRG shall send instructions to control chips to reduce power consumption below supply levels. |
| 3.5-2 | * NRG shall give priority to devices that are more necessary than others. |
| 3.5-3 | * NRG shall send generalized instructions based on technician input to all devices on the system. |
| 3.5-4 | * Response packages shall be based on what devices are currently in use. |
| 3.5-5 | * All responses shall include instructions for devices not currently being used to request a power use value when turned on. |
| 3.5-6 | * The RF shall constantly reassess its response package based on the most recent predictions and commands from the CIF. |

**3.2 Non-Functional Requirements**

This section contains the NRG Non-Functional Requirements. Non-functional requirements are numbered “NF - n” where “n” indicates the nth requirement.

NF - 1 NRG shall have a database capable of storing city-wide data on grid usage, weather patterns, and device data.

NF - 2 NRG shall require a Wi-Fi network for each device to connect to.

**3.3 Hardware Requirements**

This section contains the NRG Hardware Requirements. Hardware requirements are numbered “H - n” where “n” indicates the nth requirement.

H - 1 A central control unit capable of managing grid usage for an entire city.

H - 2 Control chips embedded in each NRG compliant device on the grid.

H - 3 A control terminal for emergency control of NRG.

**…………………………**

**4.0 Project NameDETAILED DESIGN**

**\*\*\*\*\*\*\*\*\*\*\* this section shall be developed in cs437 \*\*\*\*\*\*\*\*\*\*\***

In this section the **Project Name** described in Section 2 with requirements listed in Section 3 shall be designed in detail including several higher level DFDs. Each major module detailed design is included in correspondence with the design sections defined in Section 2 and responding to the requirements listed in its correlated sub-section in chapter 3.

The detailed design of each of the four modules discussed in section 2 with requirements presented in section 3 is presented in the Figures below.

**5.0 Project Name ELEMENTS OF IMPLEMENTATION**

**\*\*\*\*\*\*\*\*\*\*\* this section shall be developed in cs437 \*\*\*\*\*\*\*\*\*\*\***

In this section (some of) the modules designed in Section 4 with requirements listed in Section 3 shall be implemented initially at the level of pseudo code. Actual code shall be provided as time permits. Each module is implemented in correspondence with the design sections defined in section 2 and responding to the requirements listed in its correlated sub-section in chapter 3.

**6.0 Project Name TEST PLAN**

**\*\*\*\*\*\*\*\*\*\*\* this section shall be completed in cs437 \*\*\*\*\*\*\*\*\*\*\***

**6.1 INTRODUCTION**

In this section the testing methodology to be used to V&V each of the requirements listed in section 3.0 has been identified. At points some additional testing may be required and they shall be documented as an attachment to this document.

The methodologies and testing strategies identified at this point include three major approaches with various variations to adapt to the **Project Name** project:

* Testing using additional ad-hoc created software including a correlation testing unit.
* Demonstration of the specified capability
* Inspection of the software code possibly using additional inspection techniques

**6.2 FUNCTIONAL REQUIREMENTS VALIDATION MATRIX**

The **Project Name** Functional and Performance Requirements Validation Matrix is given below.

**\*\*\*\*\*\*\*\*\*\*\* this sub-section shall be developed in cs437 \*\*\*\*\*\*\*\*\*\*\***

1. **DATA DICTIONARY**

**Device Data** – Data received from devices embedded with NRG Wi-Fi remote chip.

**Historical Data** – An accumulative collection of past grid usage data that include weather pattern and daily consumption used to predict future energy deficit.

**Peripheral Device** – Any devices embedded with NRG Wi-Fi remote chip.

**Power Data** – Information about power usage demand from power plant.

**Weather Data** – Current real-time data on weather forecast that affect the demand on power usage.

1. **ACRONYMS**

**NRG -** Networked Redistribution Grid

**SRD -** Software Requirement Document

**SDD -** Software Design Document

**SID -** Software Implementation Document

**STP -** Software Test Plan

**PF -** Predictive Function

**DMF -** Data Management Function

**CIF -** Control Interface Function

**UIF -** User Interface Function

**RF -** Response Function

**DFD -** Data Flow Diagram

**TP -** Test Plan

**V&V -** Verification & Validation

**TBD -** To Be Determined