Design of One Chip Communication Stack Processor and MMS Communication Stack Library Based on IEC 61850

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A set of standards associated with “Power systems management on information exchange”

Include the application of modern networking to electrical power substation automation such as

- Requirement – define quality requirements (reliability, maintenance, security, …)
- Configuration – define system configuration
- Protocol – define network protocol requirements
- Testing – define test requirements

MMS (Manufacturing Message Specification), GOOSE (Generic Object Oriented Substation Event), SV (Sampled Value)

Run over TCP/IP networks and/or substation LANs

- High speed switched Ethernet (response times with < 4 ms)
Network Processor based vs. Legacy IEDs

Mapping is required.
Core Functions of IEC 61850

- Standardized mapping instead of numbers or indexes in Legacy IED
  - Easy to be implemented by IEC 61850 library

- Abstract Communication Service Interface (ACSI)
  - Easy to create messages between application and many devices

- Independent network protocol in a substation
  - Possible to be applied to all network protocol

- A configurable language
  - Exchange information between IED and client
Properties of Data Objects
- Common logical node information (e.g. name, health, position…)
- Status Information (e.g. status of functions)
- Settings (for operation functions)
- Measured values (e.g. CT, VT…)
- Controls (e.g. ON / OFF)
- Protection

Functions of Logical devices. e.g. XCBR: circuit breaker

Collections of Physical devices

Devices for Protection, Measurement, Control
**System Layer of IEC61850(1)**

- **ACSI (Abstract Communication Service Interface):**
  - Interface for the client and server communications
  - Abstract data structure for IED
  - Support
    - Real-time data access and retrieval
    - Device Control
    - Event reporting and logging
    - Communication between Sender (publisher) and receiver (subscriber)
    - File transfer capabilities

- **SCSM (Specific Communication Service Mapping):**
  - Abstract data is mapped to specific standardized data (MMS, GOOSE, SV)
GOOSE (Generic Object Oriented Substation Event):
- Used for sending trip messages to IED
- Multicast
- Time Limit of GOOSE is less than 4ms
- Send 3 times
- Layer 1 and 2 of OSI 7 Layers are used

MMS (Manufacturing Message Specification):
- Interface between Users and IEDs for data exchange
- Used for reporting and requesting IED status
- Change operating status of IED
- All of the OSI 7 layers are used

SV (Sampled Value):
- Sent to users from merging unit
- Values of current and voltage
What is Intelligent Electronic Device (IED)?

Functions of IED

- Protection
  - Of over current and earth fault

- Control
  - Local and remote control

- Monitoring
  - Circuit-break condition, trip circuit, gas density, relay temperature
  - Event recording

- Metering
  - Of currents, voltages, active power, reactive power

- Communication
  - With a control center and other IEDs
The legacy IED consists of 3 H/W boards
- **Measurement Control**
  - CT/PT processor module: Converts analog (CT/PT) to digital
  - Main processor module: Manages total operation of IED
- **HMI control**
  - Logic Processor module: Controls logic and peripherals, and performs function of IED
- **IEC 61850**
  - IEC 61850 processor module: Performs IEC 61850 communication S/W
  - Communication module: Performs communications with other IEDs
Structure of Proposed IED

- IEC61850 Network Processor = Logic Processor Module + IEC 61850 Processor Module
Advantages of OneChip SoC

- The Legacy IEC61850 board is big size and power consumption
  -> OneChip SoC is smaller, lower power
- Long developing time in legacy IEC61850 board
  -> OneChip SoC skips the board development
- Convenience of maintenance and repair – just replaced by SoC, not a board
- OneChip SoC is 5 times cheaper than of legacy boards
Advantages of IEC 61850 Library

- Programming by OOP, easy to revise and analyze IEC 61850 library
- Expandabilities and readabilities
- Convenient GUI
Development Goal

- IEC 61850 Network Processor
  - OneChip SoC
  - IEC 61850 Library
  - Logic Editor
Develop Procedure of IEC 61850 Network Processor

Procedure 1
- IEC 61850 Library
  - SCL Configurator
  - Service
  - Communication
- Logic Editor

Procedure 2
- IEC 61850 Platform
  - IEC 61850 Processor
  - Logic Processor
  - FPGA
  - 10/100/1000 Ethernet, I/O

Procedure 3
- IEC 61850 OneChip SoC
  - Dual Processor
  - 10/100/1000 Ethernet, I/O
# Platform for OneChip SoC

<table>
<thead>
<tr>
<th>Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Two ARM 926EJ-S</td>
</tr>
<tr>
<td>FPGA</td>
<td>Xilinx vertex 5</td>
</tr>
<tr>
<td>High Speed Memory</td>
<td>DDR2 SDRAM (SO-DIM M)</td>
</tr>
<tr>
<td>Communication</td>
<td>2-channel UART</td>
</tr>
<tr>
<td>Video</td>
<td>4.3&quot;(480 x 272) TFT-LCD</td>
</tr>
<tr>
<td>Audio</td>
<td>AC97 Audio Codec</td>
</tr>
<tr>
<td>Download Port</td>
<td>Xilinx Platform Flash</td>
</tr>
<tr>
<td>Power Supply</td>
<td>Micro-ATX PC Power Supply</td>
</tr>
</tbody>
</table>
### Specification of OneChip SoC

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>TSMC 0.13 Logic 1P/8M 1.2V Core 3.3V I/O</td>
</tr>
<tr>
<td><strong>Package</strong></td>
<td>BGA 528, 27X27x2.23mm</td>
</tr>
<tr>
<td><strong>CPU</strong></td>
<td>Dual ARM926 / 333MHz</td>
</tr>
<tr>
<td><strong>RAM</strong></td>
<td>64MByte</td>
</tr>
<tr>
<td><strong>Flash memory</strong></td>
<td>32 Mbyte</td>
</tr>
<tr>
<td><strong>Ethernet</strong></td>
<td>10/100/1000 MAC</td>
</tr>
<tr>
<td><strong>Other interfaces</strong></td>
<td>USB2.0,I2C,SPI,Uart,LCD</td>
</tr>
<tr>
<td><strong>I/O</strong></td>
<td>24 freely prog. PIO pins(GPIO), 8 x IRQ, 2x external DMA, 3 timer Inputs/outputs, 24-bit address bus, 16-bit data bus, Color LCD Controller, Nand Flash Controller</td>
</tr>
<tr>
<td><strong>Operating Voltage</strong></td>
<td>1.2V/3.3V</td>
</tr>
<tr>
<td><strong>Heat dissipation</strong></td>
<td>975mWatt</td>
</tr>
<tr>
<td><strong>Temp. range</strong></td>
<td>-40 to 85 °C</td>
</tr>
<tr>
<td><strong>IEC61850 Library</strong></td>
<td>Object-Oriented Programming</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td>Full IEC 61850</td>
</tr>
</tbody>
</table>
4 functions in IEC 61850 library

- **SCL Engineering**
  - Describe functions (LD, LN) in IED and substation

- **Initialization**
  - Read LD and LN Values from CID file

- **Service**
  - Create and analyze IEC 61850 MMS message
  - Encode and decode messages

- **Communication**
  - OSI 7 Layers mapping
All devices in substation are described by SCL engineering.

**SCL (System Configuration Language)**
- **XML type**
- **ICD (IED Capability Description)**
  - Describe functions of LD and LN in IED
- **SSD (System Specification Description)**
  - Describe single PWR line and LN in the substation
- **SCD (Substation Configured Description)**
  - Describe functions of the substation by merging ICD and SSD
- **CID (Configured IED Description)**
  - Describe and configure functions for each IED
**Initialization, Service, Communication**

**Initialization Module**
- **Init_SCL**
  - Functions to initialize data set and read LN, LD data from CID file.

**Service Module**
- **MMSServerRsp**
  - MMS Response Packet Creation
- **MMSReqServ**
  - MMS Request Packet Creation
- **MMSCOMMRspServ**
  - MMS Response Packet transfer
- **MMSCOMMReqServ**
  - MMS Request Packet transfer
- **REQControl**
  - Functions to manage request messages and check whether the response messages are received or not
- **MMSMpl**
  - Functions to make MMS messages for request / response.
- **MMSDecoder**
  - Functions to decode MMS messages
- **MMSOPCode**
  - Functions to map variable on MMS messages.
- **MMSMsgUtil**
  - Functions to split fields of MMS messages.

**Communication Layer Module**
- **COMMServ**
  - Functions to set or free the connection and take responsibility for receiving and sending packets.
- **ACSEServ**
  - Functions to provide OSI 7 layer environment of messages.
- **ISOPP**
  - Functions to negotiate the transfer syntaxes.
- **ASN 1**
  - Functions to encode or decode response / request message to ASN. 1 format.
- **ISOSP**
  - Functions to manage session.
- **ISOTP**
  - Functions to check error.
- **GeneralSocket**
  - Functions to manage packets for actual communication.
1) server shows data value
2) client reads data from the server
3) client writes data to server
4) confirm data of server
Conclusion

- Developed network processor (OneChip SoC and Library) for IEC 61850 will be core functions in Smart Grid
- Network processor with high reliability, small size, low power and short period time of development
- Library with expandabilities and readabilities by OOP
- It is easy for users to develop an IED by providing one pass network processor