
STUDIO
ELEKTRONIKE
RIJEKA
Od ideje do proizvoda.

WAMSTER – Ad hoc WAM System

Keywords: *hand-held PMU, ad hoc networking, WAM, R&D tool*

Motivation

High prices of control devices and additional installation costs are the main reasons that prevent collecting of electrical system in-depth data necessary in R&D projects. For project involving PMUs as data generators, data aggregation or averaging over a larger period of time is not acceptable, and the amount of created data becomes a major concern in the planning phase of an "experiment". The usage of available utility communication system in dedicated R&D project opens several technical and security issues that take money and, above all, time to be solved properly. In a pretty active timetable for WAM/WAMPAC and other synchrophasor projects proposed by NASPI, mentioned issues can prolong or even entirely prevent gathering of necessary data at some measurement points. Also, accessibility of communication infrastructure decreases by aging of plants under consideration and with lowering of voltage level. Consequently, just LV measurement points with general purpose Ethernet in vicinity can be used for PMU data collecting purposes in independent, short term or low cost R&D projects. Upon authors' opinion, a solution to remedy mentioned difficulties and to ease academia and small R&D teams getting involved in synchrophasor highway should be provided.

Solution

WAMSTER project was started at Studio Elektronike Rijeka (STER) at the end of 2009 as a coordinated work with Department of Electric Power Systems Faculty of Engineering, University of Rijeka (RITEH). WAMSTER is a proof of concept for technology that is to be further engaged in Croatia Academic WAM (CARWAM) network.

Concept established by WAMSTER can be considered as a "wireless worldwide data" PMU source and concentrator. WAMSTER system is targeting to solve practical obstacles for "a small R&D team" involved in PMU surveys worldwide. It uses globally available GPRS network and Internet accessible server as a data collecting channel. Prevention of data loss due to large and highly unpredictable communication delays and high probability of GPRS communication interruption are resolved by an adaptive communication scheme, along with battery backup and dedicated flash memory on each PMU device.

Modification of modest, but robust and proven PQ measuring platform into a handheld PMU device lowers development and production costs. Therefore, developed PMU can be used by itself as a "low cost PMU generator", or can be integrated with WAMSTER system as a source for "self-sufficient PMU data collecting & archiving system".

Benefits

WAMSTER system is consisted of:

- multiple easy-to-use handheld PMUs, equipped with GPS and GPRS modem (presented on Fig. 1 and Fig. 2)
- dedicated server for R&D hosting purposes and serving of real-time and historical data to web clients
- system administration and data archiving, presentation and export application.

Fig.1: STER PMU device

Developed phasor measurement unit provides measurement of 4 voltage synchrophasors. Voltage range selector provides 3 ranges: 150 V suitable for 100 V systems and VT connection, 300 V for 230V systems and 1000 V for large industrial LV installations. Measurement data creates synchronous stream for four voltage synchrophasors. Additional four current inputs are currently used for development purposes, and will be re-included in data stream after completion of the development phase in august 2010. Instrument's front-end consists of dual 4-channel 16-bits synchronous sampling ADC. ADC sampling frequency is adapted to mains frequency in order to form 64 samples-per-period windows. Windows are formed and tagged according to the IEEE C37.118 standard. Synchrophasors are calculated by FFT calculation performed on non-overlapping, rectangular window of data and saved to instrument's flash memory at synchronous speed. Instrument has a battery backup sufficient for 8 hour operation.

In normal PMU reporting operation, most recent packet of phasors is reported at synchronous speed (50 frames per second) to the WAMSTER server through GPSR link as soon as possible, from each connected PMU device. In case of interruption in communication link, this can result in packets being dropped from the PMU data stream. When a missing packet is detected in the incoming stream, WAMSTER server immediately issues a command that collects missing data from instrument's flash memory. Missing data will be reported to server after communication channel regains its full speed profile.

In case of permanent reduction of communication capability, missing data alarm will repeatedly activate regaining procedure and a list of missing packets at server will start to increase. To deal with this situation, server will issue a "sub-synchronous reporting speed" command that will reduce PMU reporting to 25, 10 or 1 frame per second (for 50 Hz systems). This will allocate more communication resources for collection of missing data because instrument's flash memory of 8MB permits 133 minutes of autonomy. After that time, any non reported data will be overwritten and permanently lost. When the communication link has been fully reestablished, server will increase the speed to its nominal value.

There is also an alternative reporting scheme provided by WAMSTER that is particularly

useful in cases when WAMSTER serves as a PDC for a superior WAM system. In condensed mode, single PMU frame is sent to the server each second for system health check purposes. In case of a detected disturbance, or upon user request, WAMSTER server will issue requests to all PMU devices to start collecting data from instrument's flash memory stored at synchronous speed (50 frames per second), for the requested time span only. This way, communication and data storage requirements are significantly reduced during normal operation.

At present (beginning of June 2010), system is at its mature prototyping phase. There are 8 PMUs operable. Three units are used for measurement and protocol development. Numerous custom tools are built to ease development on usual office desk shown on Fig. 3. External 6-channel sound card (in the upper left corner) is used as a fully controllable signal generator. Five units are engaged in communication endurance test. Fig. 5 presents test setup with instruments on left, modems on right, power supply on the middle of the table and antennas hanging at the window.

Communication and administrative part of server application is fully functional. Status of the WAMSTER services can be seen using the WAMSTER Server Management Console (shown on Fig. 6). Communication status can be observed for each device separately, as shown in Fig. 7, which confirms that data flow breakages occasionally happen (caused by rebooting of server, black-out simulation and antennas disconnection) but missing PMU sets are successfully gathered (light blue blocks represent packets which have been lost, but successfully received "on-request").

Web GUI application is still under development, as additional features are being added according to customers' suggestions. Demo web application (displaying actual measurements from several devices) can be accessed at www.ster.hr/wamster/ (shown in Fig. 8.

Fig.2: Fully equipped PMU with a carrying bag

Fig.3: Unit in development phase

Fig.4: Recorded data (from instrument's flash memory) can be analyzed offline

Fig.5: Communication endurance test setup

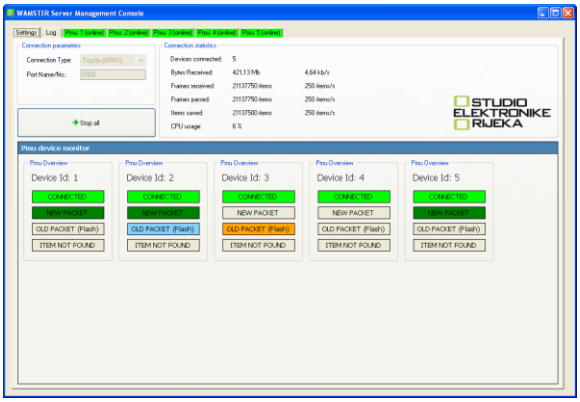

Fig.6: Overview of WAMSTER status

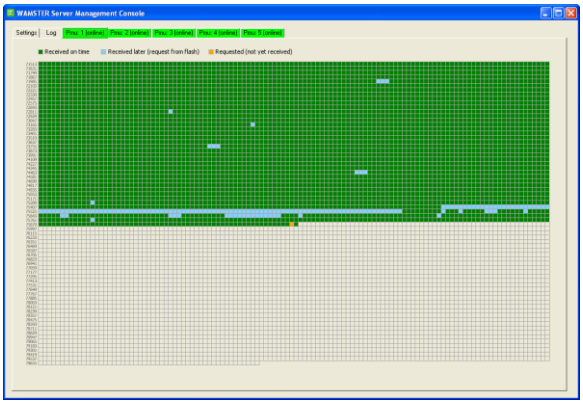

Fig.7: Detailed collection map

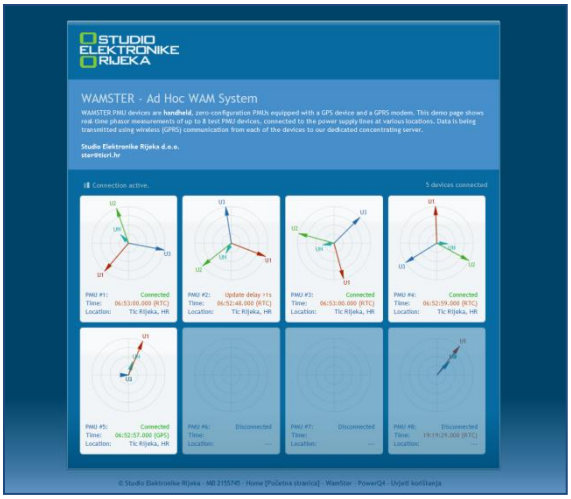

Fig.8: On-line synchrophasors status window

Future Directions

WAMSTER will be fully operational and ready to deploy and in production in September 2010 with a supply ability of more than **100 units** till end of a year. At that time, measurement algorithm will also be ported to 60 Hz systems and thoroughly tested.

Web application is currently accessible at www.ster.hr/wamster, with basic functionality such as viewing real-time phasors, examining historical or detailed trend charts, and comparing measurements of several devices simultaneously. Additional web functionality will be gradually implemented under suggestion of our colleagues at RITEH or potential customers. Beside completion of web application, imperative of WAMSTER development in future months will be implementation of data exchange with superior WAM or SCADA systems starting with CARWAM.

STER will also take effort to extend the use of portable STER PMU devices outside of WAMSTER system. PMU devices will have IEEE C37.118 protocol implemented until September. A development of RS232 to Ethernet converter, which would allow devices to be used without a GPRS modem, is also under consideration.

Contact Information

CARWAM: Srđan Skok, RITEH
[srdjan.skok@riteh.hr]

WAMSTER: Dalibor Brnobić, STER
[dalibor.brnobic@ster.hr]

References

[1] **Skok, S.; Sturlic, I.; Matica, R.:** Multipurpose open system architecture model of wide area monitoring, 2009 IEEE Bucharest PowerTech

[2] **Brnobić, D.; Vlahinić, S.; Stojković N.:** The effect of IEC grouping algorithms on frequency domain noise, Measurement, Volume 43, Issue 3, April 2010, Pages 426-433