Energy-Efficient Event-Driven Microcontroller with Atomic Event Quantization Unit for IoT Sensing Applications

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***Abstract*—The IoT sensor devices are easily implemented with the conventional microcontroller performing the discrete-time based sampling, digital signal processing, and transferring the sampled raw data into the cloud area. The syntactic sensor signal processing requires the repeated wakeup of the CPU to perform the interrupt service routines and the communication interface is activated consuming more energy for the cloud-side lazy evaluation to extract the signal event from the collected raw data. In this paper, we propose the event quantization unit for the early evaluation in the sensor processor to identify the minimum information of the sensor signal by the atomic event and its sequence. The additional hardware as a tiny accelerator, which is integrated with the conventional 8051 CPU, reduce the number of CPU wakeup and communication interface.**

I. Motivation and Proposed Architecture

The operating lifetime of the battery-operated IoT device for the activity-monitoring and sensors signal analysis [1] is dependent on the energy consumption extracting the signal event for the long-term signal activity in the entire sensor system including sensor, MCU, and communication interface. The fast signal processing in the accelerator hardware consuming the high peak current enables the fast sleep entrance, which is more efficient in terms of the energy consumption. The syntactic signal processing based on the discrete-time sampling and the cloud-side signal analysis simplify the MCU architecture, but the activity ratio of the sensor system and communication interface is increased to perform the raw-data collection from the continuously fluctuated sensor signal.

The key motivation for the proposed method starts from the transition to the macro-level processing of the sensor signal by signal-to-event conversion instead of the conventional micro-level signal analysis. The event-driven sensor digital signal processing concept is introduced as time-based sampling method [2]. Instead of conventional ADC, the signal-to-event converter as an atomic event quantization unit is implemented with the timer and comparator to identify the crossing points of the user-defined signal condition. The extracted atomic information. The early evaluation of the incoming signal before the signal processing is performed reduces the number of the CPU wakeup, interrupt service routine execution, and communication interface. The resolution of the event quantization unit can be adjusted to extract the enough information. In a case of best resolution, the proposed method results in similar effect to that of the conventional ADC-based sampling result

II. Implementation and Experimental Results

The proposed atomic quantization unit is designed as a customized accelerator, which is placed with 7500 NAND gates, and implemented on the FPGA fabric with the digital timer and level-controlled comparator, determining whether the incoming signal crosses the featured level in the specific time range. The IR(infrared radio)-based gesture activity monitoring as a case study could be performed with the reduced CPU wakeup by the proposed microcontroller architecture.

References

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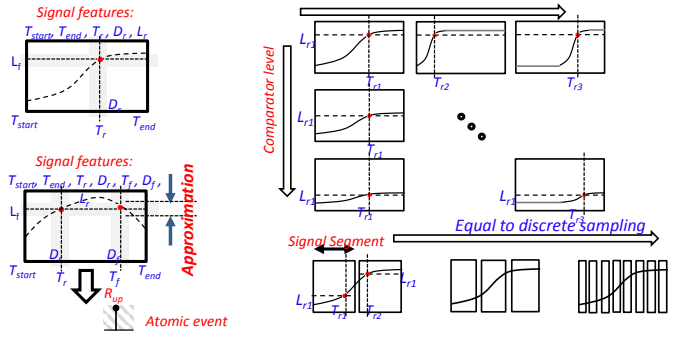

Fig. 1. Early evaluation based on the proposed atomic event quantization, determining whether the incoming signal crosses the featured points

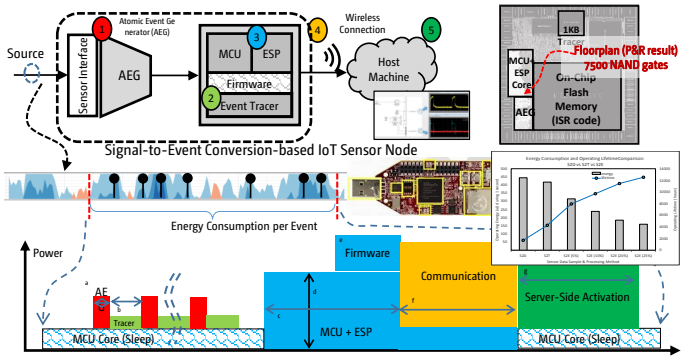

Fig. 2. Proposed MCU architecture, showing the reduction of system wakeup for IR-gesture detection