GNSS-R multi-channel correlation waveforms post-process solution for GOLD-RTR Instrument

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Abstract

Global navigation satellite system reflectometry (GNSS-R) remote sensing is a new remote sensing technique of satellite navigation applications. Essentially, it entails a method of remote sensing that receives and processes microwave signals reflected from various surfaces to extract useful information about those surfaces. ***The GPS Open-loop Differential Real-Time Receiver (GOLD-RTR) instrument*** is designed by the ICE (IEEC-CSIC) to gather global positioning satellite system signals after they have been reflected from suitable surfaces (e.g. sea, ice and ground). This configuration was first proposed in 1993 by the European Space Agency (ESA) as passive multi-static radar to monitor mesoscale ocean altimetry, currently known as global positioning satellite system reflectometry (GNSS-R) scenario. However, the increasing campaigns have put great pressure on high performance post-processing design into the space level instrumentation. In our work, the problem of ***real-time post-processing design*** is addressed in order to process the ***multichannel cross correlations waveform***. This work is to realize ***Single Correlation Integration algorithm (SCI)*** on the proposed novel platform, named as ***Heterogeneous Transmission and Parallel Computing Platform (HTPCP).*** The simulations are processed and results show that the parallel computing speed of HTPCP outperforms SMP and it is very effective in reducing memory access time and bus busy ratio and hence, is compatible for GOLD-RTR instrument.

Introduction

GNSS-R concept and scenario : GNSS signals reflected on the ocean surface are used to gather its properties like roughness or level [1]. The GOLD-RTR instrument delivers and collects the high amount of complex-valued (I and Q) cross correlations (waveform) between GPS L1-C/A signals and the reflection signals in real-time. This is a clear threat to a space borne mission where ***large amount of data must be sent from space to ground during the campaigns***.

Issues to be addressed:

1)Parallelize the inherent serial output of the GOLD-RTR instrument

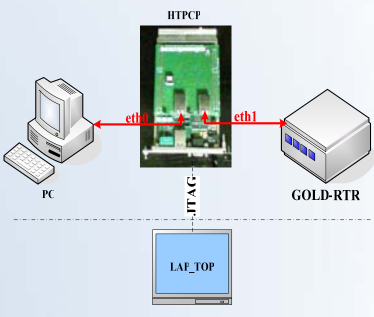
2)Post-process the multi-channel (I and Q) correlators in parallel

3)The aggregate system throughput of one second would be 12.8Mbps.

Proposed solutions:

•Implement the real-time SCI algorithm as a post-process system for GNSS-R cross-correlation waveform.

•Propose a novel on-board HTPCP architecture.



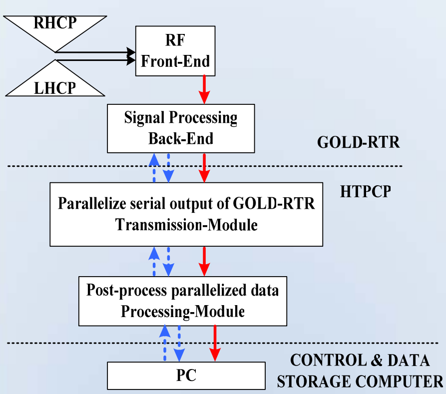
GR-CPCI-XC4V plus
GR-CPCI-2ETH-SRAM-8M

Architecture and Algorithm

GOLD-RTR and HTPCP system

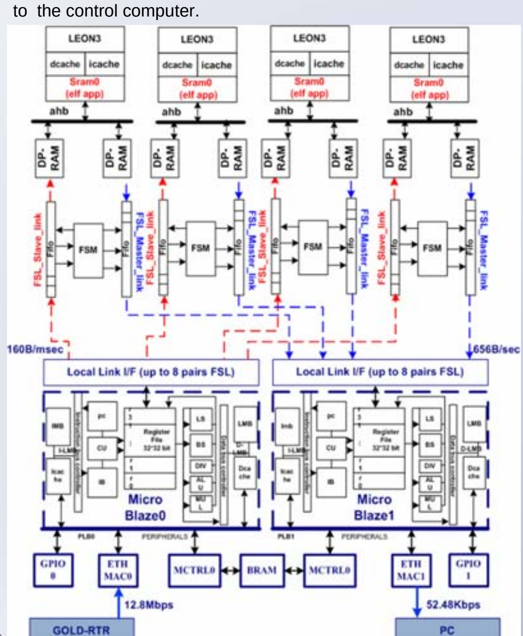
• **GOLD-RTR instrument** : RF front-end and the signal-processing back-end [1].
• **HTPCP** : Transmission Module (TM) and Processing Module (PM).

✓The **TM** is applied to parallelize the inherent serial output of GOLD-RTR.
✓The **PM** is used to realize mutli-channel SCI algorithm and reduce the amount of dump waveform prior to downlink through the satellite.



HTPCP architecture

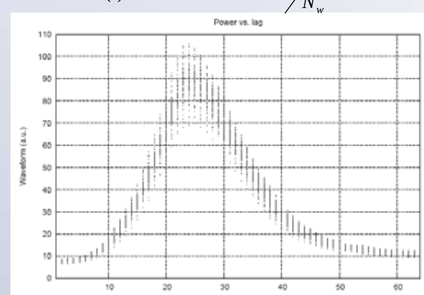
- Implement the SCI function in parallel.
- Forward transparently the control and monitoring packets between the control PC and the GOLD-RTR rack back and forth.
- Process the received waveform in parallel, and send the results to the control computer.



SCI algorithm.

The coherent integration time slot is 1 ms Every 1 s, we can always get 64 time-varying amplitude of each time slot.

$$W(i) = \frac{\sum_{j=0}^{N_w-1} \sqrt{I_i(j)^2 + Q_i(j)^2}}{N_w}$$



1) **To integrate coherently the complex data C quantities during the intervals dt_{coh}**

$$C_{coh}(lag_i, Cha_j, t_{coh}) = \sum C_{coh}(lag_i, Cha_j, T)$$

where the sum applies to all T within the interval [t_{coh}-dt_{coh}/2, t_{coh} + dt_{coh}/2], if this interval do not contain a possible navigation bit transition.

2) **To integrate uncoherently the complex data C_{coh} quantities during intervals dt_{uncoh}**

$$C_{uncoh}(lag_i, Cha_j, t_{uncoh}) = \sum \left| C_{coh}(lag_i, Cha_j, T) \right|^2$$

where the sum applies to all *T* within the interval [t_{uncoh}-dt_{uncoh}/2, t_{uncoh} + dt_{uncoh}/2]. In our case, dt_{coh} will takes one of the values (1ms, 2ms, 4ms, 10ms, 20ms) and dt_{uncoh} = 1s.

Results and Conclusions

A novel parallel platform, HTPCP, is presented in order to realize the real-time post-processing for GNSS-R system. Two problems are proposed and solved, 1) Parallelize the inherent serial output of the GOLD-RTR instrument and 2) Post-process the multi-channel (I and Q) correlators in parallel. The numerical results show that system throughput can reach up to about 12.8Mbps. Comparing with the state-of-the-art serial SW solution, the processing time of SCI algorithm can improve about 19%. The coherent integration time can improve 8.17 times comparing with the conventional Symmetric Multiprocessing (SMP) [3]. And the parallel computing speed of HTPCP outperforms SMP. It is very effective in reducing memory access time and bus busy ratio and hence, is compatible for GOLD-RTR instrument.

In **further work**, we need to improve the efficiency of co-processing function, and further increase the number of parallel processors, in order to make it suitable for more real-time applications of GNSS-R. E.g. to calculate the sea surface mean-square slopes, ice roughness and thickness, soil moisture and biomass etc...

References

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