GNSS Software Receiver and Its Applications

Yang Gao

Tsinghua GNSS Lab

Contents

- The Concept of GNSS Software Receiver
- STARx: Tsinghua University's Software-defined Tunable All-GNSS Receiver
- Applications of GNSS Software Receiver

Contents

- The Concept of GNSS Software Receiver
- STARx: Tsinghua University’s Software-defined Tunable All-GNSS Receiver
- Applications of GNSS Software Receiver

Why Software Receiver?

- The rapid development of satellite navigation field
  - Each GNSS continues to evolve new navigation signal structures
  - More and more new receiver processing algorithms are proposed to adapt to different application environments

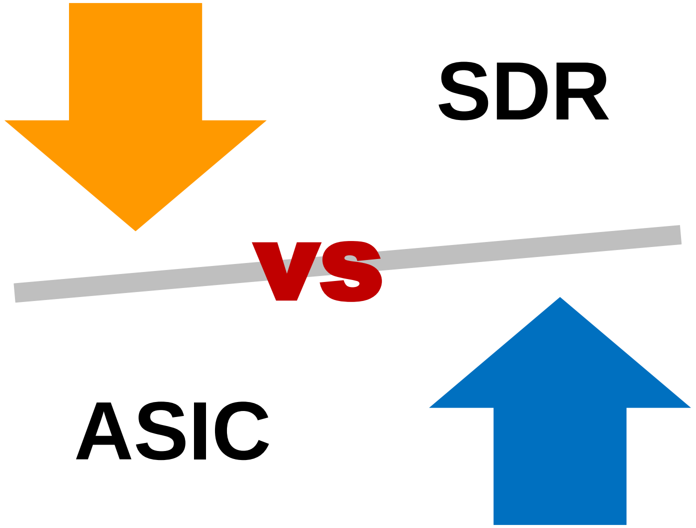
- Software-Defined Radio (SDR)
  - Highly flexible and highly scalable SDR architecture is more responsive to this rapid development

Software Receiver Concept

- Definition of SDR
  - SDR is a radio communication system where components that have been typically implemented in hardware are instead implemented by means of software on a personal computer or embedded system.
- Purposes of SDR
  - Move the analog to digital converter (ADC) as close as possible to the antenna front-end
  - All baseband functions are processed in a programmable microprocessor using software techniques

Software Receiver Concept

- Advantages of SDR
  - Lower development costs
  - Higher flexibility
  - Stronger scalability
  - Better portability
  - Shorter development cycle



Software Receiver Architectures

Tsinghua University

- GNSS receiver platform comparison

Technology	Development Costs	Performance	Power Consumption	Single Unit Costs	Flexibility
ASIC	--	++	++	++	--
FPGA	-	++	+	-	+
DSP / CPU	++	+ / ++	+ / --	+ / -	++
Hybrid FPGA / CPU	+	++	+	-	+
CPU+GPU*	++	++	--	--	++

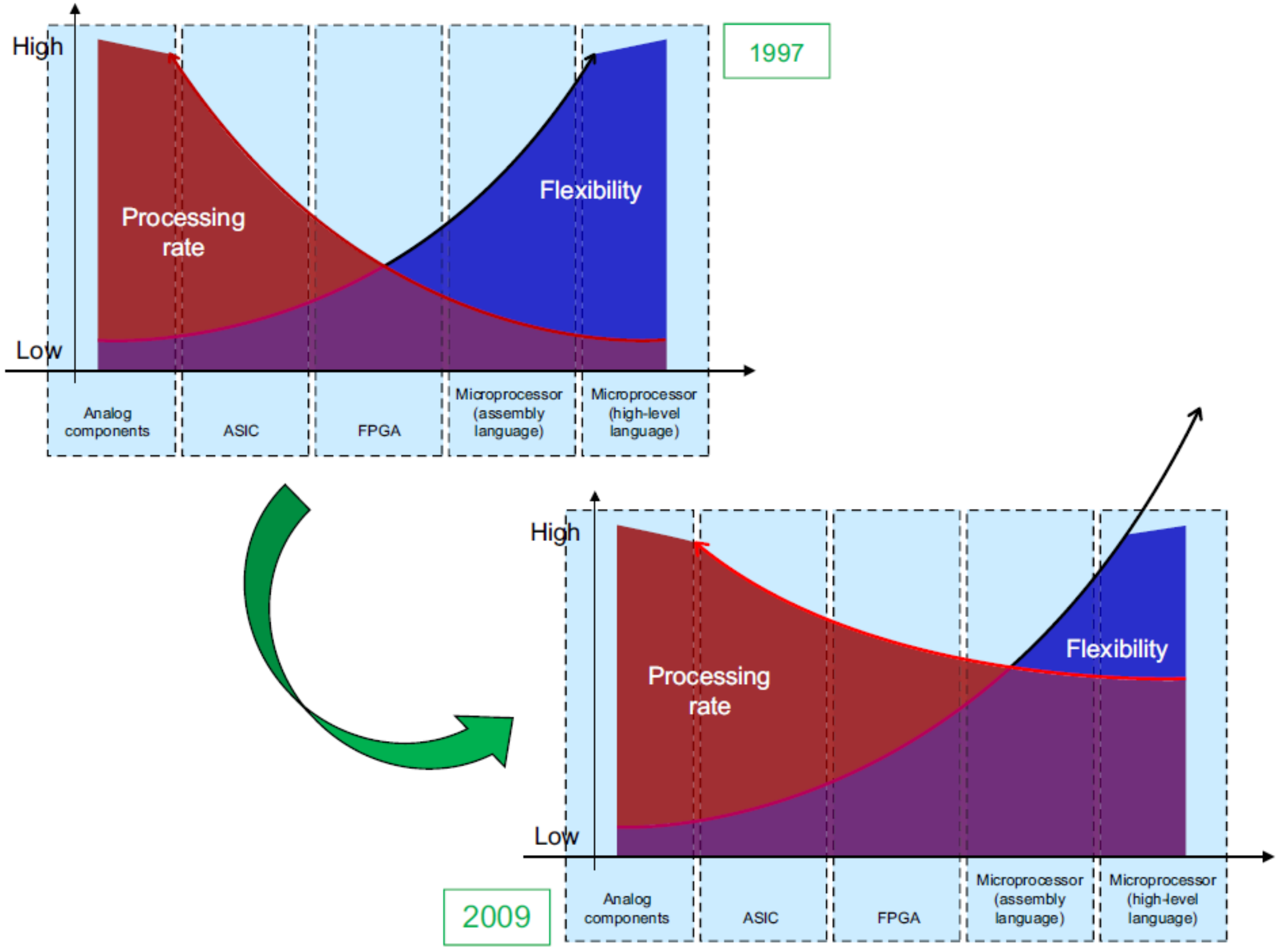
Table 1: GNSS technology comparison, from (++) major advantage to (--) major disadvantage[1].

[1] Hein G, PANy T, WALLNeR S, et al. Platforms for a future GNSS Receiver[J]. Inside GNSS, 2006, 1(2): 56-62.

* This technology was proposed in recent years and is increasingly receiving a lot of attention with the rapid development of GPU parallel acceleration capability.

Software Receiver Trends

- Performance Trends
  - Flexibility is traded for processing speed
  - Trend is more and more advantageous for SDR



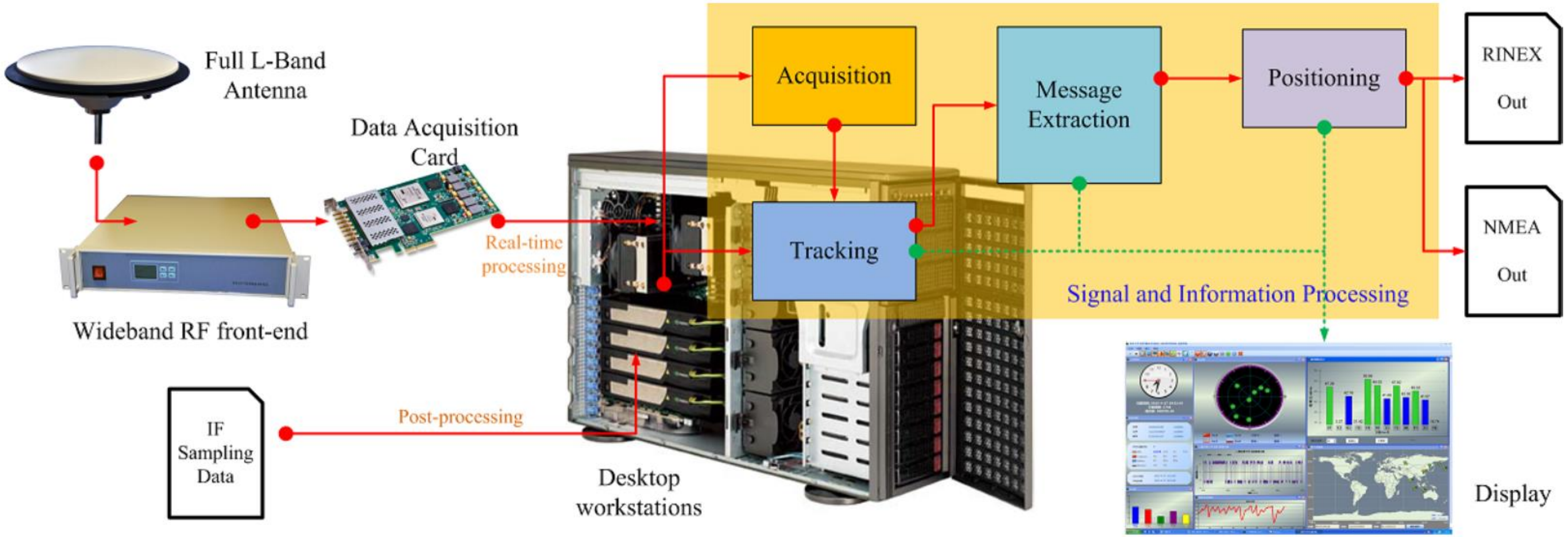
[1] Dardari D, Falletti E, Luise M. Satellite and terrestrial radio positioning techniques: a signal processing perspective[M]. Academic Press, 2012.

Contents

- The Concept of GNSS Software Receiver
- STARx: Tsinghua University's Software-defined Tunable All-GNSS Receiver
- Applications of GNSS Software Receiver

STARx Architecture

- STARx: Tsinghua University's Software-defined Tunable All-GNSS Receiver



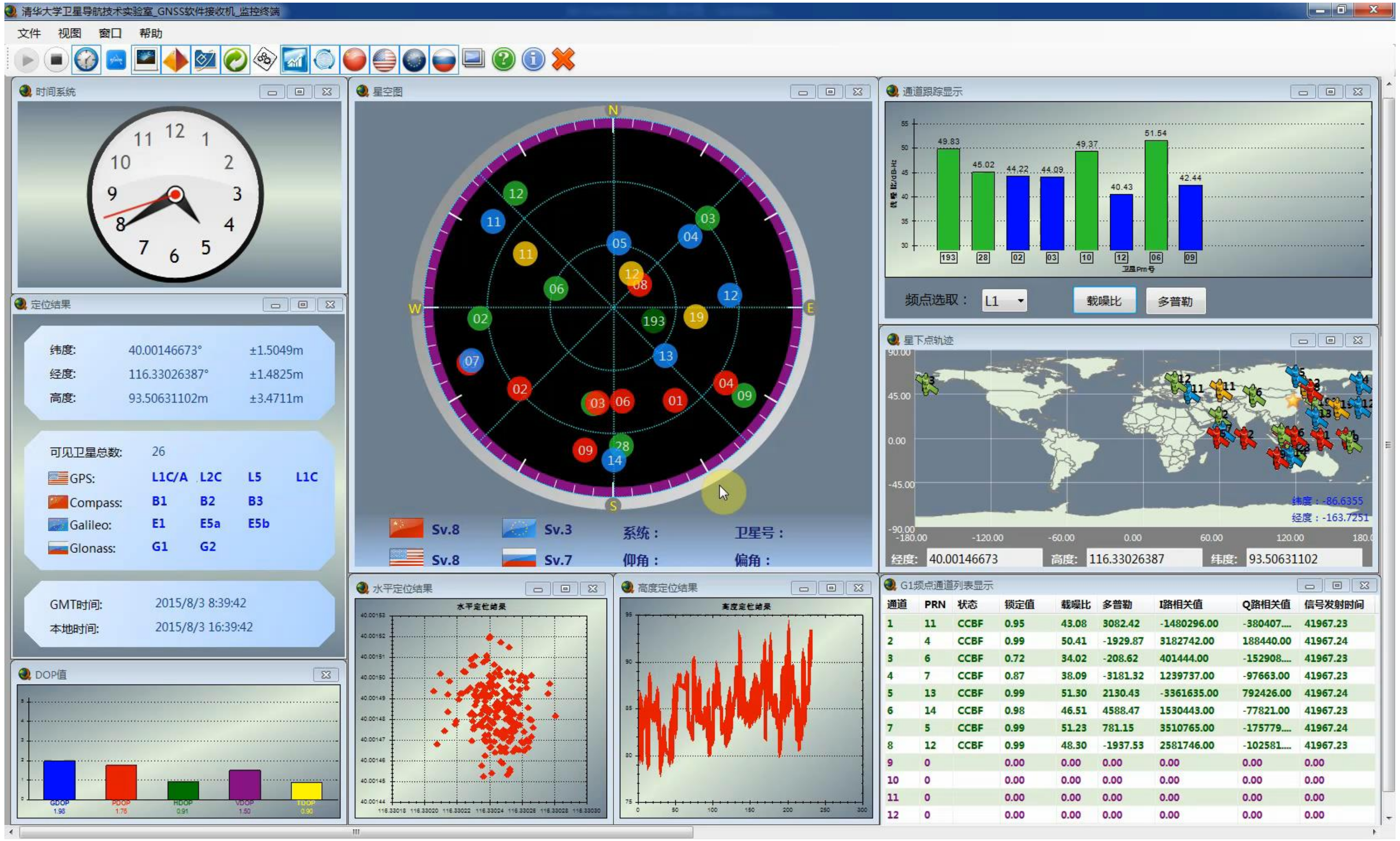
[1] Huang, B., Yao, Z., Guo, F., Deng, S., Cui, X., Lu, M., "STARx -- A GPU Based Multi-System Full-Band Real-Time GNSS Software Receiver," Proceedings of the 26th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2013), Nashville, TN, September 2013, pp. 1549-1559.

STARx Characteristics

- Fully Functional
  - Multi-system (BDS, GPS, Galileo, GLONASS, QZSS)
  - Full-Band (all of the civil signals from above systems)
- SDR Architecture
- GPU Based Real-Time Processing
  - High-speed parallel signal processing algorithms
- Modular Design

STARx: Real-time Software Receiver

- STARx Demo



Contents

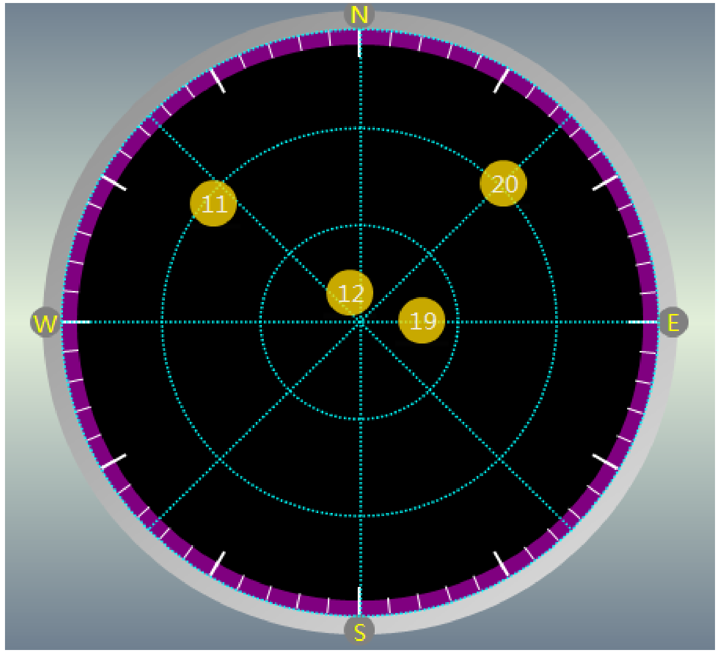
- The Concept of GNSS Software Receiver
- STARx: Tsinghua University’s Software-defined Tunable All-GNSS Receiver
- Applications of GNSS Software Receiver

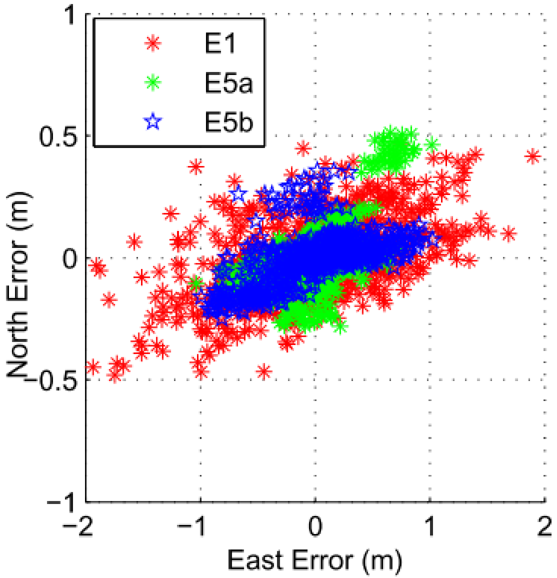
Software Receiver Applications

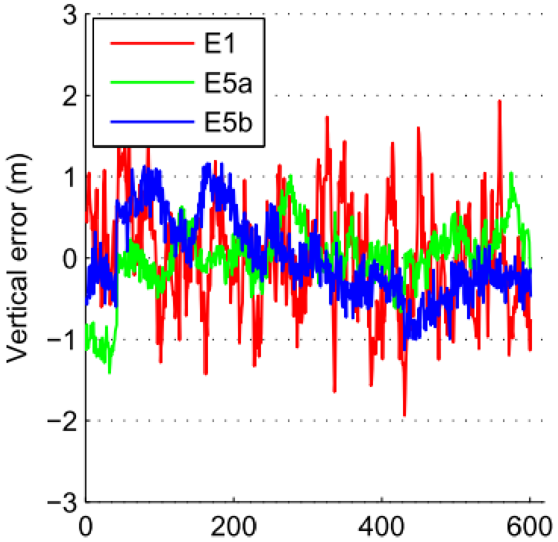
- Monitoring and Assessment of GNSS Signal Quality
- Analysis and Assessment of GNSS Signal Performance
- Analysis and Assessment of GNSS Compatibility and Interoperability
- Research on GNSS Receiver Algorithm and Prototype Development
- Measurement, Evaluation and Calibration of GNSS Signal Simulator
- Research and Education

Signal Observation and Performance Analysis

- Galileo E1, E5a, E5b
  - On May 5 2013, STARx successfully received 4 satellite signals from Galileo system in Beijing and completed the three-dimensional positioning for the first time in China.

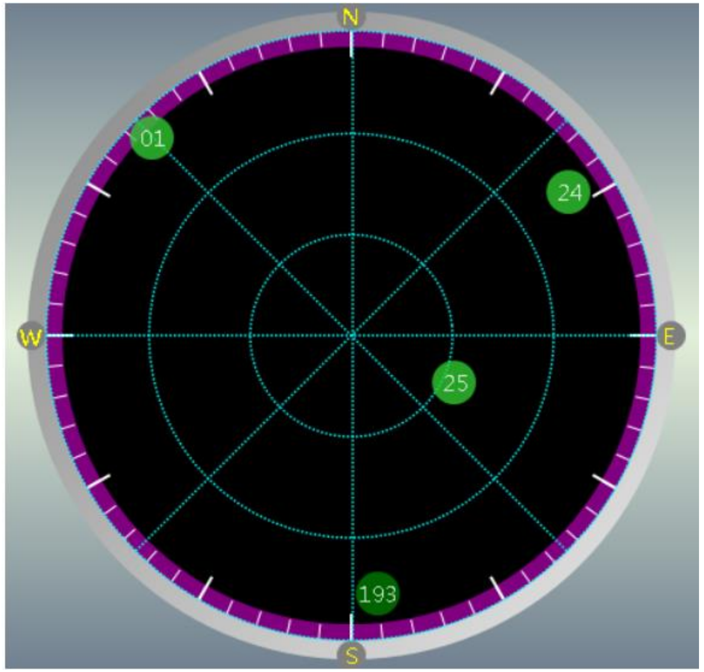


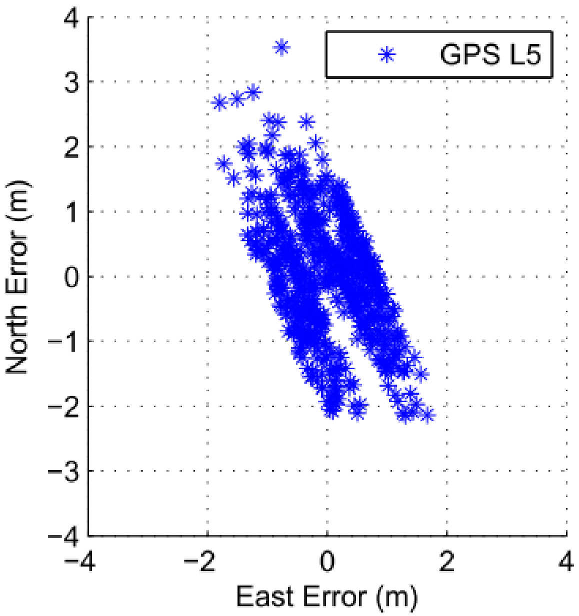


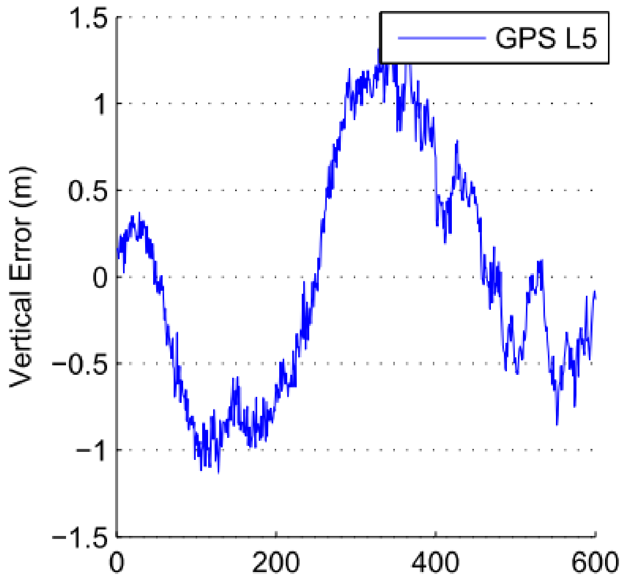


Signal Observation and Performance Analysis

- GPS L2C, L5
  - The U.S. Air Force Space Command announced that the GPS would have a live-sky test for the modernized civil navigation (CNAV) for the first time on June 2013, STARx successfully captured the L2C and L5 signals and achieved positioning by using each signal alone.



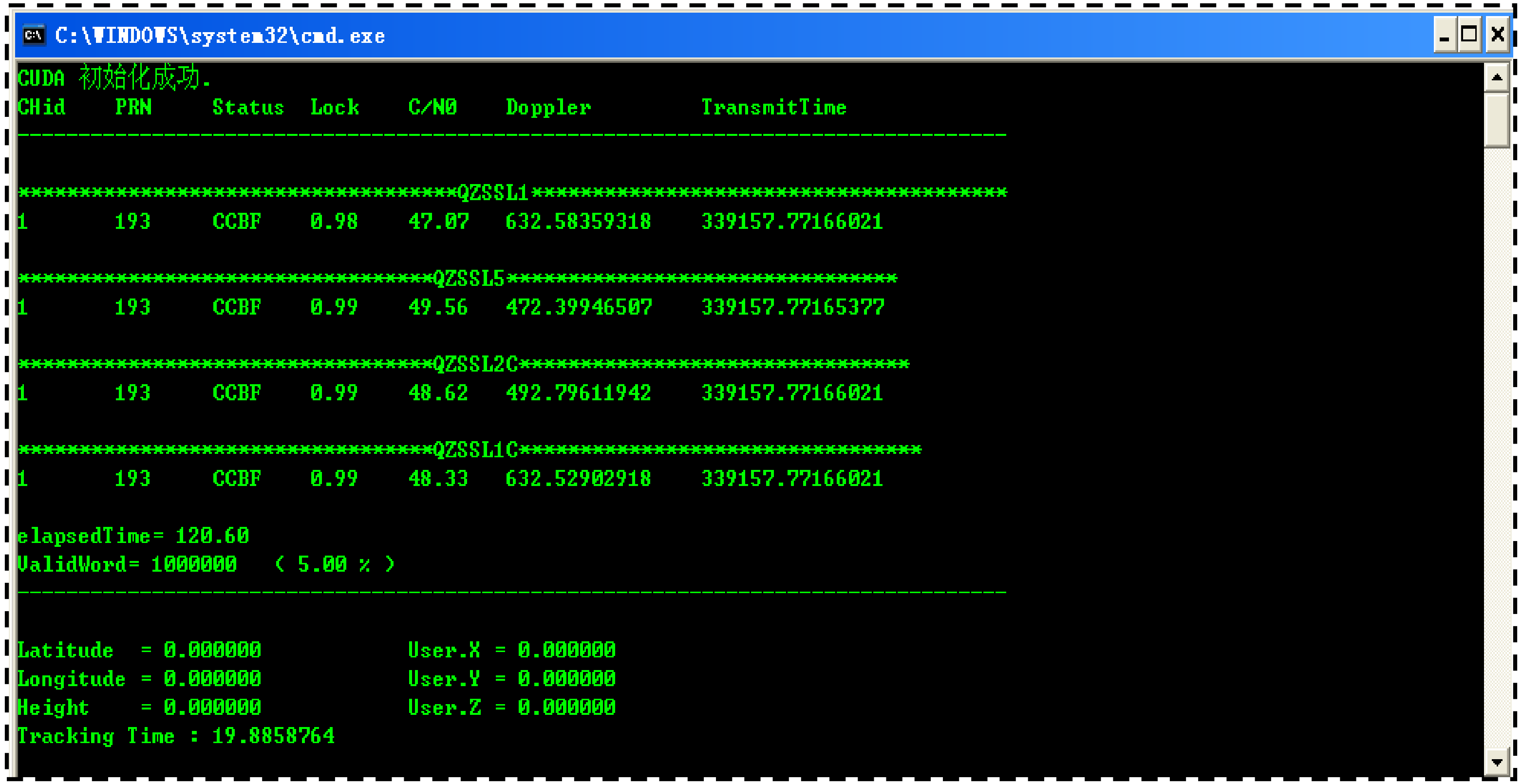




Signal Observation and Performance Analysis

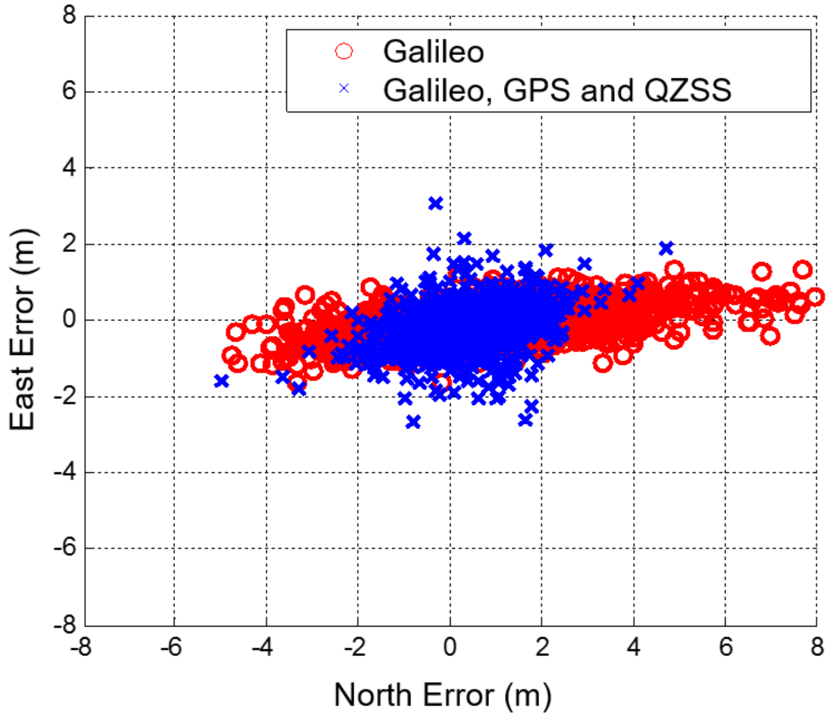
Tsinghua University

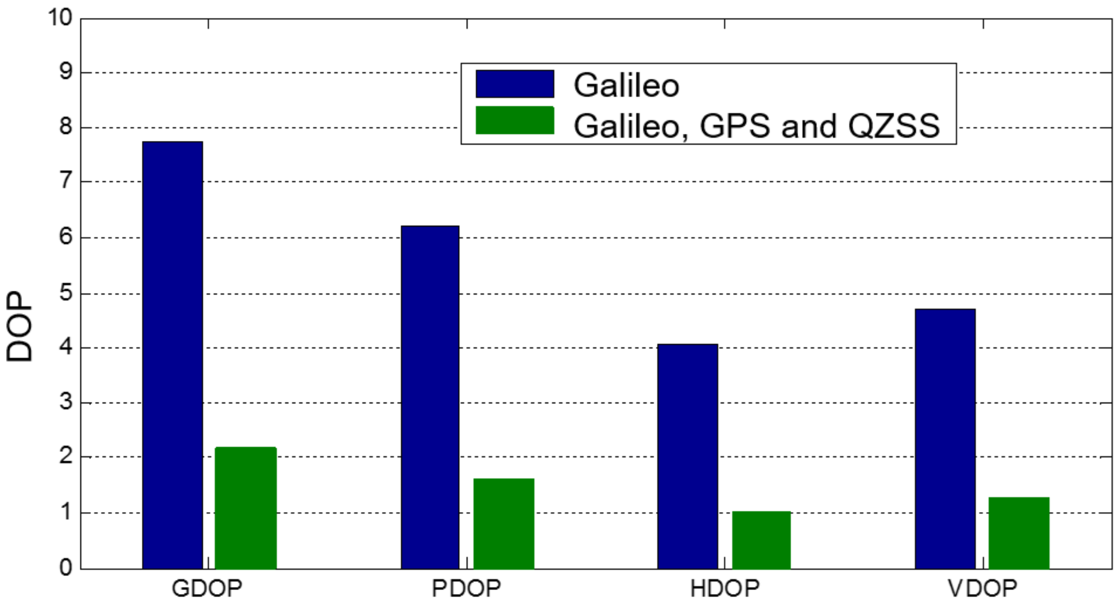
- QZSS L1 C/A, L2C, L5, L1C
  - STARx successfully completed 4 satellite signals tracking from QZSS and completed the message extraction.



Signal Observation and Performance Analysis

- GNSS Joint Positioning on the L1 Frequency
  - On May 2013, STARx successfully completed the three-dimensional joint positioning with GPS L1, QZSS L1 and Galileo E1 for the first time in China.





Conclusion

- Highly flexible and highly scalable SDR architecture is more responsive to the rapid development of satellite navigation signal structures and processing algorithms
- A high-flexibility multi-system full-band real-time GNSS software receiver becomes relatively easier to be developed by using the GPU parallel acceleration capability on an ordinary personal computer
- There will be more and more common applications of GNSS software receiver because of its gradually lower cost per unit