System Architecture for Server-Based Network-RTK Using Multiple GNSS

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Integrating the Generations FIG Working Week 2008
Stockholm, Sweden 14-19 June 2008

CORS Networks

• Infrastructure for high accuracy applications
• CORS networks are being established at an ever increasing rate around the world
• Used for long-term geoscientific studies… geodesy
• But also provides the basis for RTK positioning and augmentation services… surveying & spatial industry
CORS (continued)

- "Generation 1"
  - “use-as-is” basis
  - No guarantee of service
  - Small number of service subscribers
  - Standard RTK
  - Network RTK

- "Generation 2"
  - Multiple GNSS
  - Ultra-high accuracy
  - CORS-based services
  - Legal traceability
  - Integrity
  - Quality assured services

SydNet

Standard RTK available
AuScope

Over 100 new CORS in next 3 years

IGS Real-Time Pilot Project

Free real-time products & data streams being established over the next 3 years
R&D Challenges

• Designing the *appropriate* IT components
• Longer baseline and network algorithms utilising the *new* GNSS signals
• New data processing models based on *different configurations* of CORS and user GNSS receivers
• Delivering products by a variety of *new* wireless communication links
• Incorporating *new* value-added services

Data Management Considerations

• Data capacity assumptions (Australia)
  – >100 CORS
  – ≥3 GNSS means >40 satellites visible
  – 1Hz data
  – 1,000 or more simultaneous users
• Quality control and data integrity
• DBMS
RTK Services: Options

- Conventional single-base RTK vs Network-RTK (NRTK)
- Conventional rover-based RTK vs Reverse RTK (RRTK)
- Server-based RTK (SRTK)
  - NOT an antonym of Rover-based RTK
  - NOT a synonym of Reverse RTK
  - “System of systems approach” that includes single-base RTK, NRTK, RRTK, post-processing, ?
  - Architecture modes? e.g. Centralised vs Distributed

Single-base RTK vs NRTK

- **Single-base RTK**
  - Single reference station
  - Simple algorithm & implementation
  - Short baseline length
    - UHF ~10km
    - Internet ~20km or more

- **NRTK**
  - Multiple (≥ 3) reference stations
  - Computational overhead
  - Synchronisation & latency challenges
  - Lower number of satellites in use
  - Longer baseline lengths
Rover-based RTK vs RRTK

• **Rover-based RTK**
  - Reference station(s) send corrections to rovers
  - 1:m relationship (unlimited users)
  - Standardised data transfer (e.g. RTCM)
  - Variety of algorithms at reference station(s) and at rover(s)

• **RRTK**
  - Rover(s) send “raw” data
  - Reference/control station sends coords to rover(s)
  - 1:1 relationship (limited users)
  - Computational overhead to handle multiple rovers
  - Latency problem
  - Data quality assurance
  - Increased accuracy
  - Longer baseline length

Example: Server-based **Network-RTK**

• Resolve integer ambiguities within CORS stations
• Compute residual vector
• Compute "network parameters"
• Generate "synthesised measurements" (SM), *e.g. Trimble VRS measurements or Leica iMAX measurements*
• Conventional NRTK
  - Allow rover to perform NRTK with SM
• Reverse NRTK
  - Server to perform NRTK with SM
Network Integer AR

- Goad (1992)
  - Rounding of wide-lane and iono-free integer ambiguities
- Teunissen (1995)
  - Least-squares ambiguity decorrelation adjustment
  - Kalman Filtering

Typical Server-based Processing Algorithm

- Receive and decode raw measurements
- Check the measurements
- Form single-differenced (WL, L1, ion-free)
- Form DD (WL, L1, ion-free)
- Compute WL ambiguity from coordinate
- Fix wide lane ambiguity for all stations (round up based on a simple criterion)
- Accumulated epoch number > n?
- Initialize DD L1 float ambiguity
- Using a Kalman filter to estimate DD L1 float ambiguity and RT2D
- Fix ambiguity (round up based on a simple criterion)
- Update

Comments
- Data from ALL Rxs?
- What is "output"? Ambs? Network parameters?
- Processing "engine(s)?"
- Service other NRTK processes, e.g. VRS, FKP, iMax?
- Datum maintenance issues?
- Server/system architecture?
System Architecture

Server-based Network-RTK:
VRS Example

Local, national
global CORS

Centralised?

Distributed?
Vendor/SP?

Std or Reverse?
Comments

• Preserve maximum flexibility in configuration modes for RTK and Post Processing
• Accommodate variety of implementation modes, including mix of owners-operators-SPs
• Permit expansion/adaption to incorporate new RTK/NRTK developments, including PPP
• More easily integrate "next gen" CORS operations for surveying, into tier of real-time GNSS geodesy infrastructure

Concluding Remarks (1/3)

• Network-RTK improves accuracy and reliability of real-time rover coordinates
• Server-based RTK is a new concept for GNSS surveying
• In GNSS geodesy, server-based network processing has always been the norm, though not in real-time
• With the move of the IGS towards a “real-time future”, the distinctions between server-based network-RTK implementations for survey users and for geodesy will increasingly be blurred
Concluding Remarks (2/3)

• A real-time integer ambiguity resolution procedure that uses multiple reference baselines is more reliable than one using single-base
• The wide-lane ambiguity is first fixed, then the primary ambiguity and relative tropospheric zenith delay are estimated using the ionosphere-free combinations and an adaptive Kalman filter
• A server-based RTK system architecture is proposed … a demonstration system is currently under development

Concluding Remarks (3/3)

• The example of computing VRS corrections for server-based network-RTK is presented to illustrate the process
• A system architecture for server-based network-RTK is proposed that incorporates distributed-computing
• The proposed system design should cope with simultaneous requests from hundreds of clients
• New business models based on a variety of implementation & reference-rover configuration modes will be possible