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

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Samsung Lim & Chris Rizos, *System Architecture for Server-Based Network-RTK using Multiple GNSS*

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***

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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

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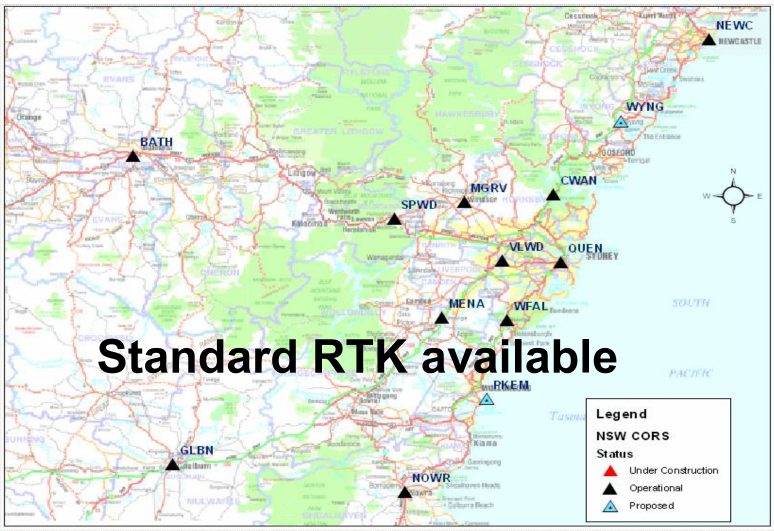
SydNet



Standard RTK available

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AuScope

Over 100 new CORS in next 3 years

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IGS Re

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

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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

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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

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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

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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

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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

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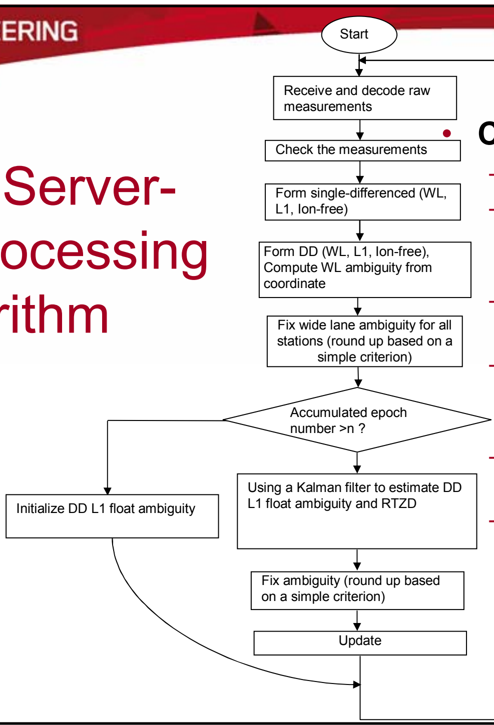
Network Integer AR

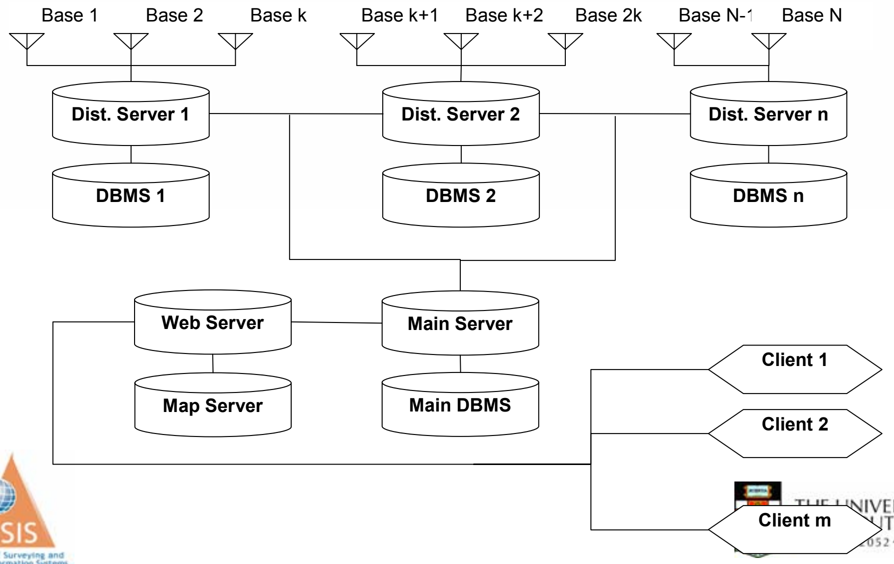
- Goad (1992)
  - Rounding of wide-lane and iono-free integer ambiguities
- Teunissen (1995)
  - Least-squares ambiguity decorrelation adjustment
- Hu et al (2003)
  - Kalman Filtering

Typical Server-based Processing Algorithm



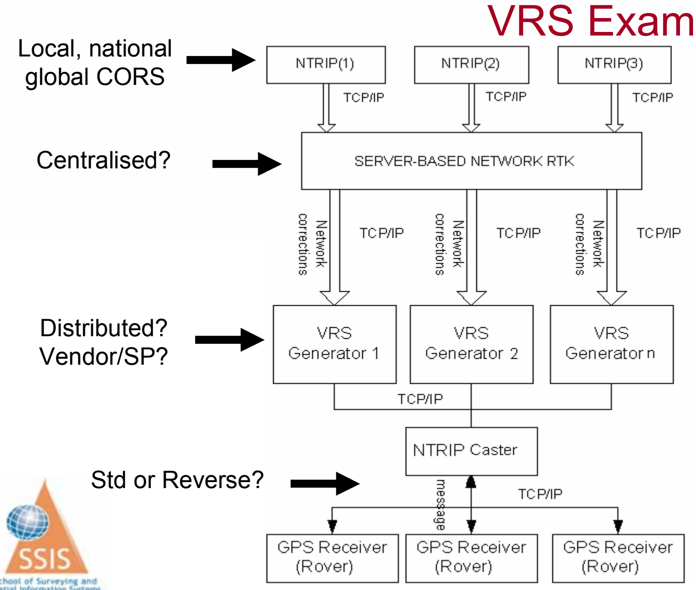
- **Comments**
  - Data from ALL Rxs?
  - What is "output"? Ambs? Network parameters?
  - Processing "engine(s)"?
  - Service other NRTK processes, e.g. VRS, FKP, iMax?
  - Datum maintenance issues?
  - Server/system architecture?

System Architecture



Server-based Network-RTK:

VRS Example



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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

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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

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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*

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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

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