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Navigation with Cellular CDMA Signals

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Motivation

Global navigation satellite system (GNSS) is at the heart of autonomous vehicles navigation systems. However, GNSS signals are unreliable due to:

- Severe attenuation in deep urban canyons
- Intentional and/or unintentional jamming
- Spoofing!

Approach: Exploit SOPs

Ambient signals of opportunity (SOPs) may enhance and assist conventional navigation techniques.

Challenges

- **Unavailability of SOP models for navigation purposes**
- **Unavailability of receiver architectures for navigation observables extraction**
- Unknown SOP emitters' states (position and clock)
- Less stable clocks than GNSS satellite vehicles

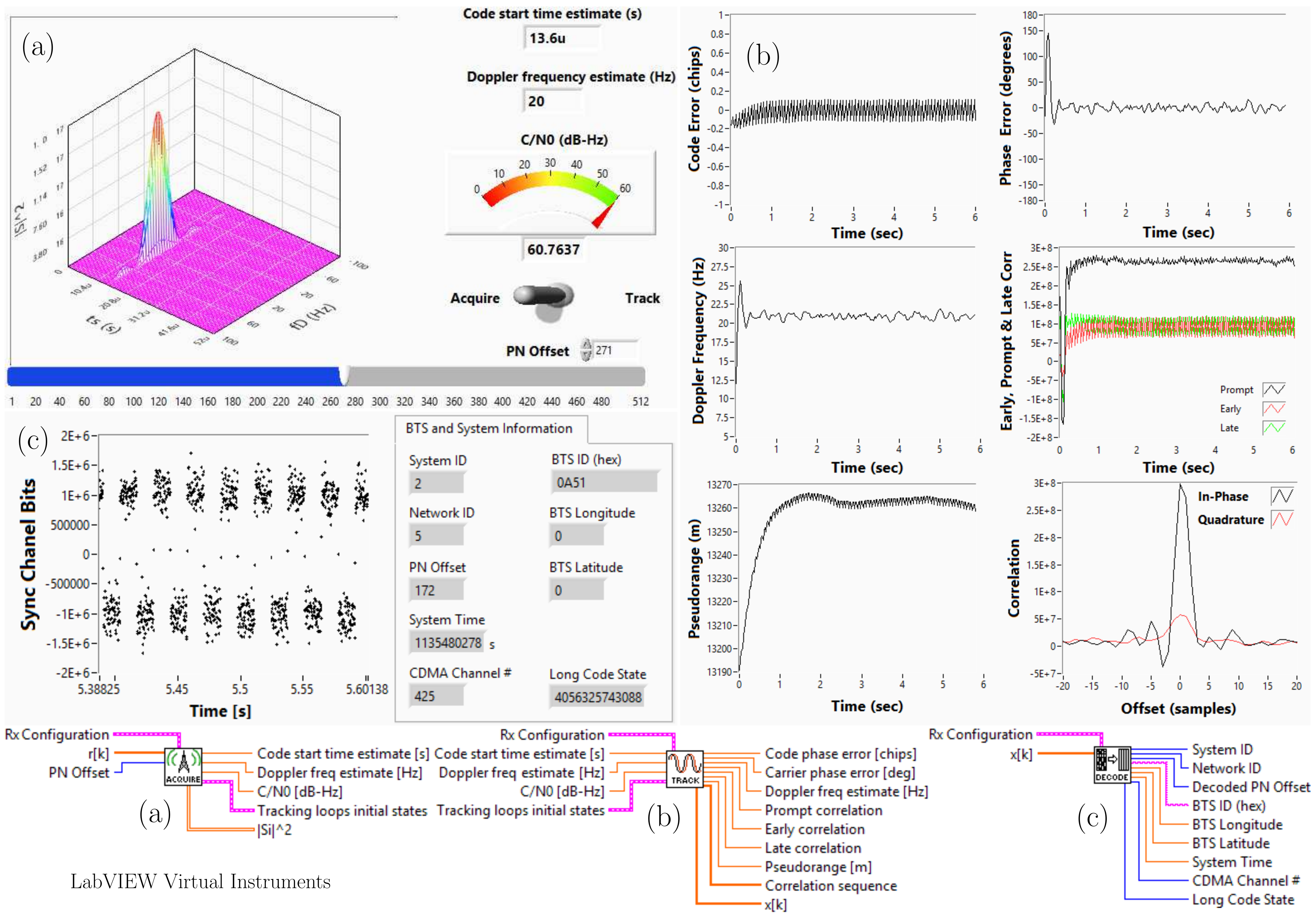
Cellular CDMA as SOPs

- Uses code division multiple access (CDMA), which is suitable for ranging
- Abundant and free to use
- Higher received power and bandwidth than GNSS

Cellular CDMA Navigation Software-Defined Receiver

We implemented a cellular CDMA software-defined radio in LabVIEW to optimally extract relevant timing and positioning information. Although these signals were intended for communications, we were able to model them in terms of navigation observables. The receiver has three stages:

(a) Acquisition: Signals from different BTSs are identified and a coarse estimate of their corresponding code delay and Doppler frequency is obtained.
(b) Tracking: These estimates are maintained and refined via tracking loops.
(c) Decoding: The message transmitted by the BTS is decoded and relevant information is extracted.



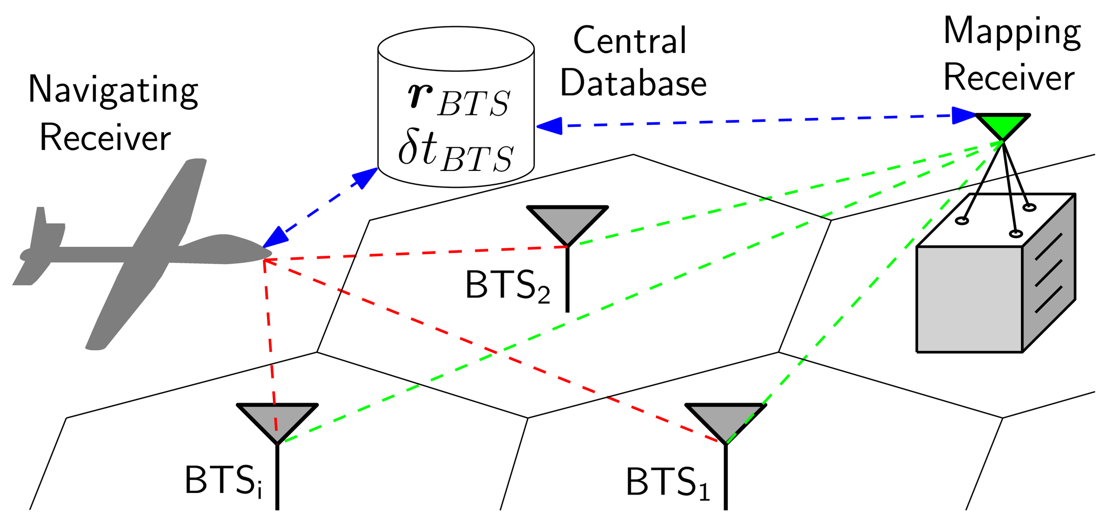
LabVIEW Virtual Instruments

Navigation Framework

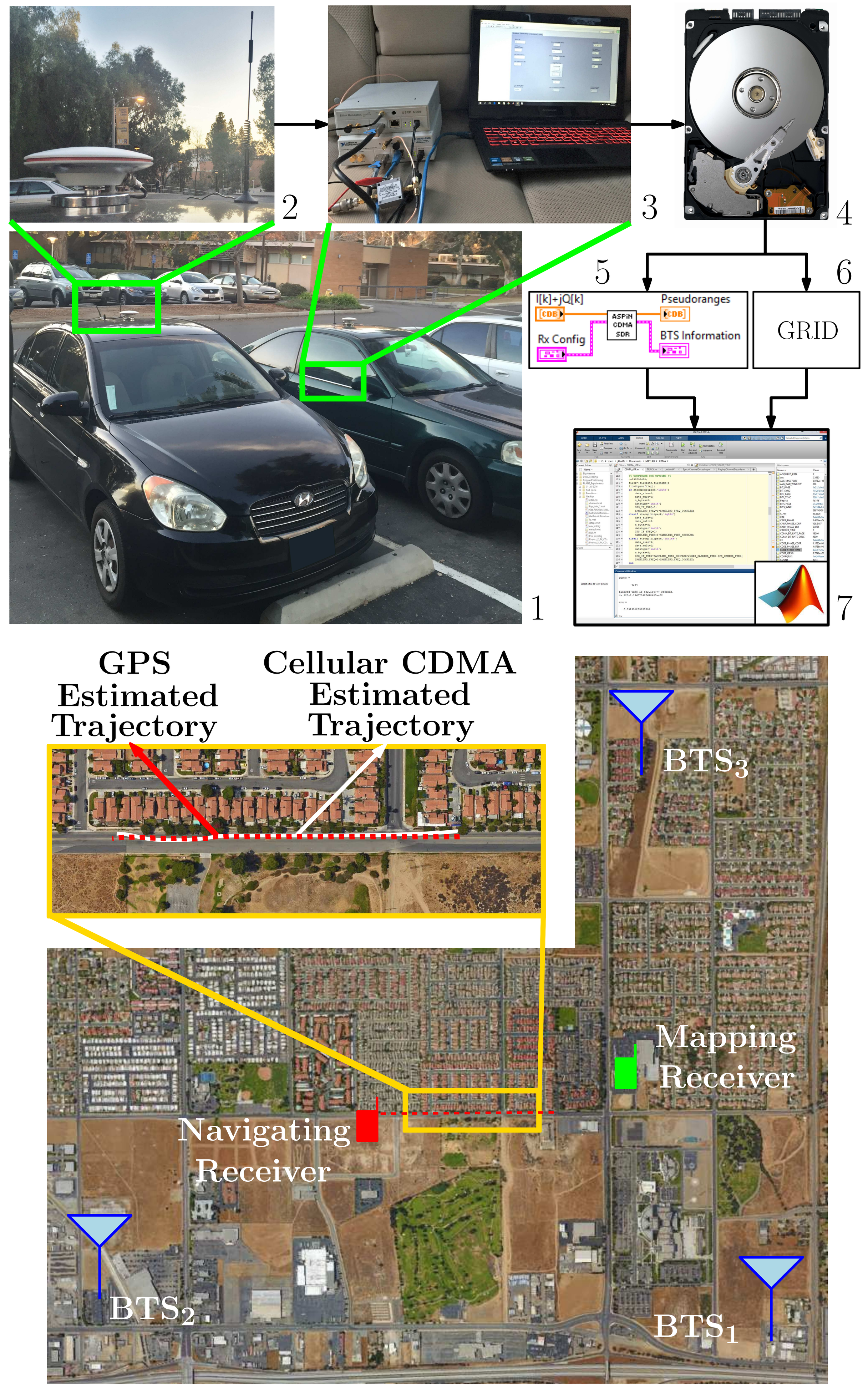
The pseudorange measurement ρ is given by

$$\rho = ||\boldsymbol{r}_r - \boldsymbol{r}_{BTS}||_2 + c \cdot (\delta t_r - \delta t_{BTS}) + v,$$

$\boldsymbol{r}_r$: receiver position	$\boldsymbol{r}_{BTS}$: BTS position
δt_r: receiver clock bias	δt_{BTS}: BTS clock bias
v: measurement noise	c: speed-of-light



Experimental Demo



Mean Error: 5.51 m   Standard Deviation: 4.01 m

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