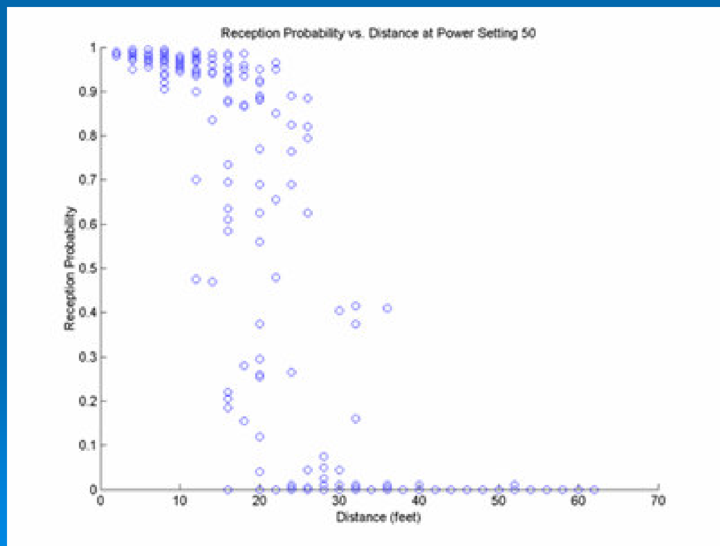
I. RSSI and Ad-Hoc Networking

Portions adapted from
Kamin Whitehouse
And Crossbow

Design Principles

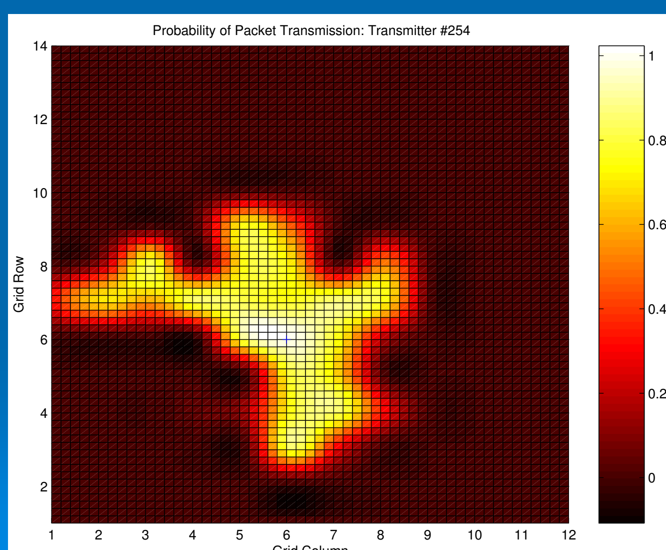
- Node-level Resolution
- Scalable Deployment
- Event-driven
- Simple and Approximate Operation

Radio Ranging – Connectivity



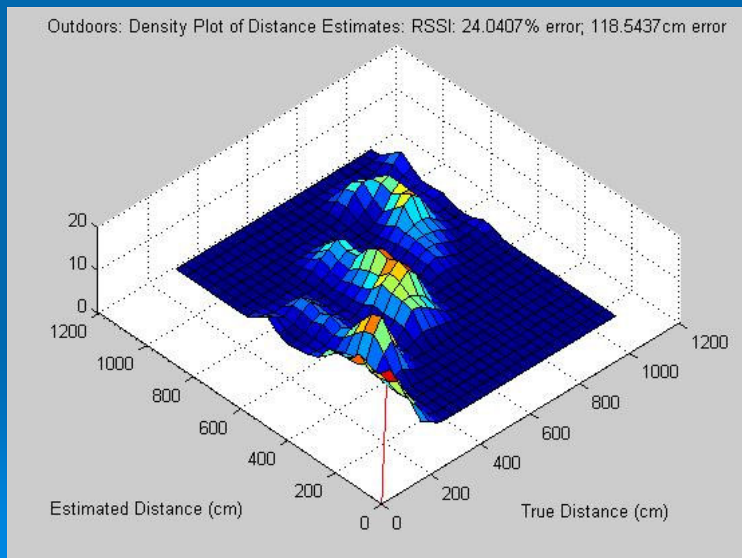
Data courtesy Alec Woo, Ganesan, et al

Radio Ranging – Connectivity

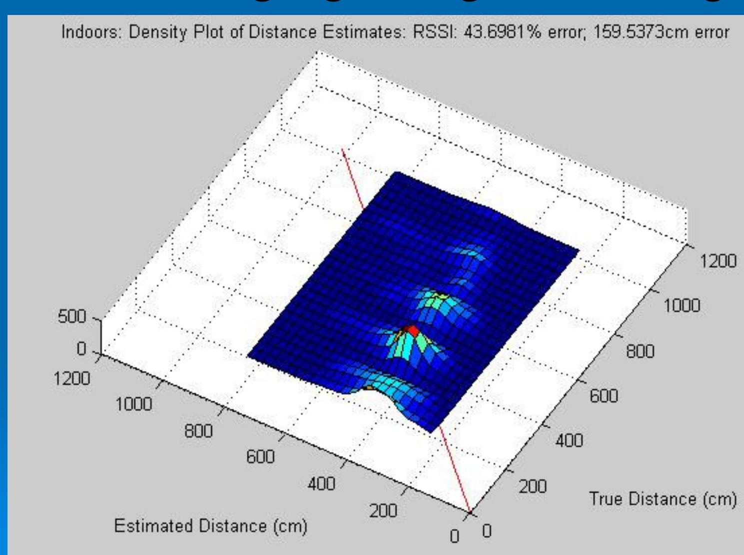


Data courtesy Alec Woo, Ganesan, et al

Radio Ranging – Signal Strength



Radio Ranging – Signal Strength



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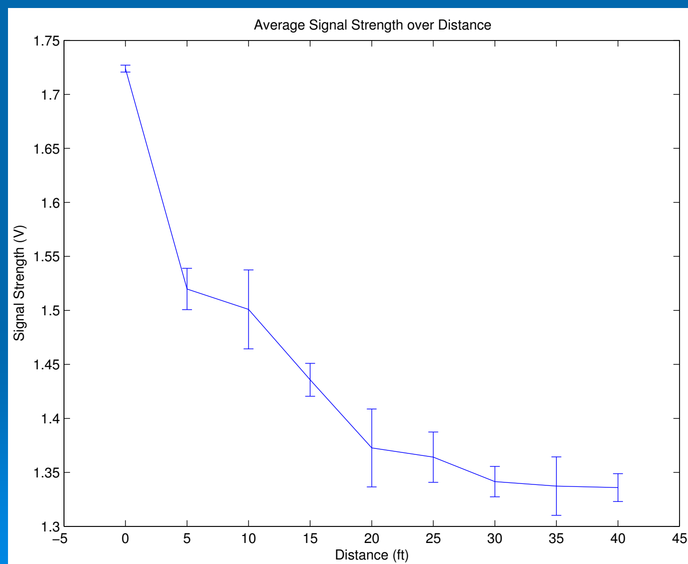
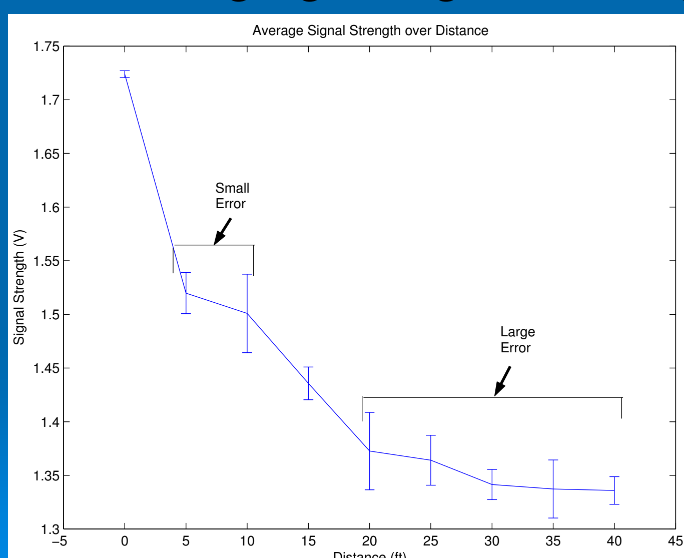


Radio Ranging – Signal Strength

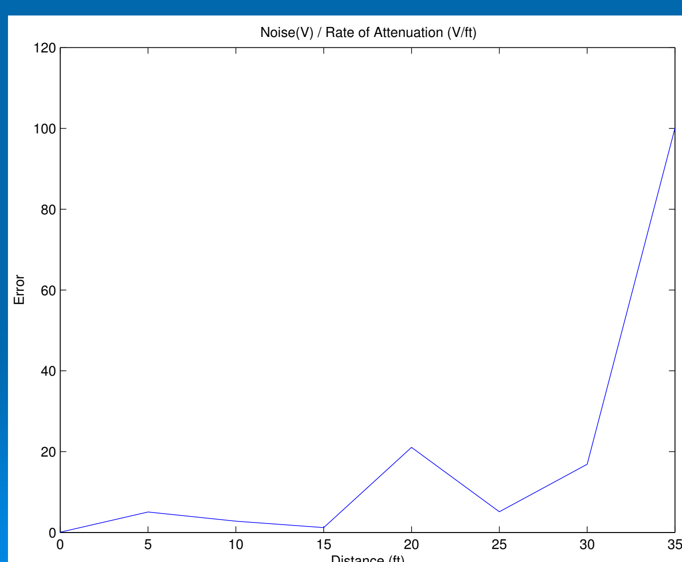


Radio Ranging – Signal Strength

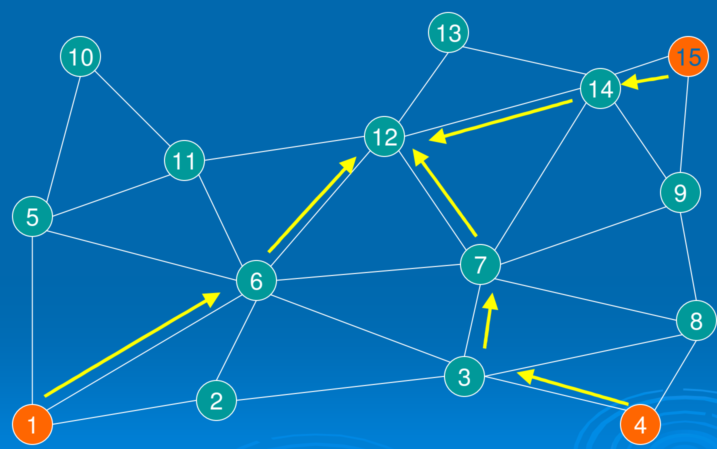
- Error equation:

$$\text{error (cm)} \approx \frac{\text{noise (dB)}}{\text{Attenuation rate }\left(\frac{\text{dB}}{\text{cm}}\right)}$$

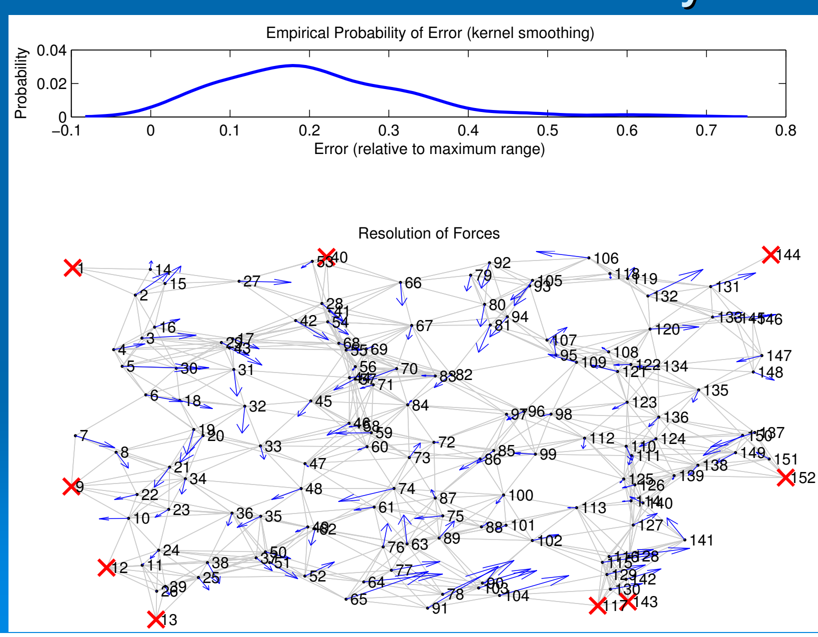
Radio Ranging – Signal Strength

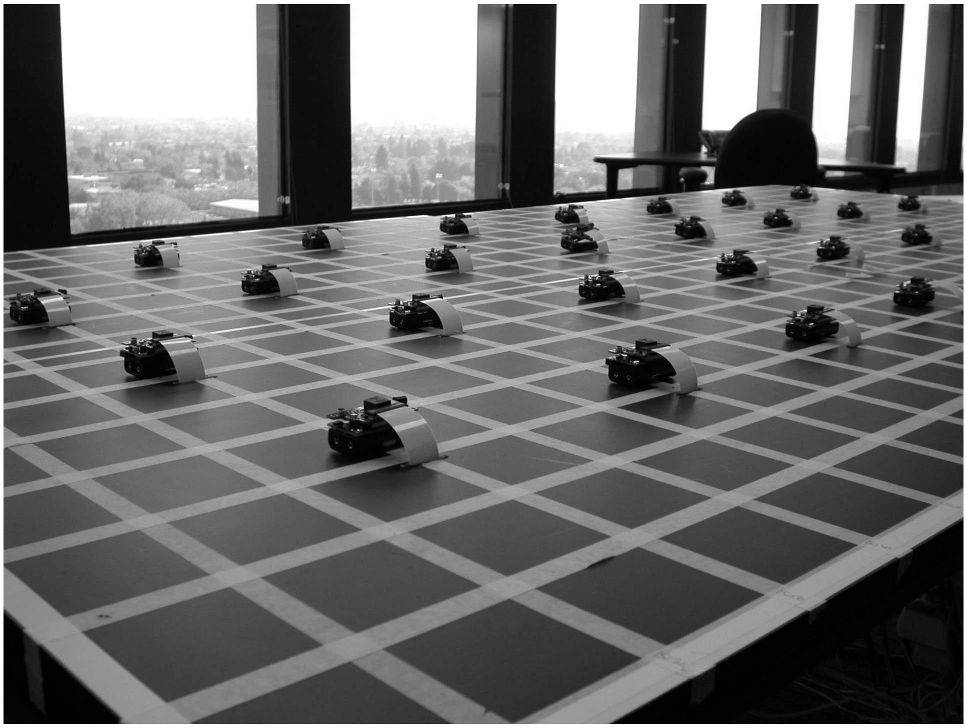


Localization



Localization Accuracy





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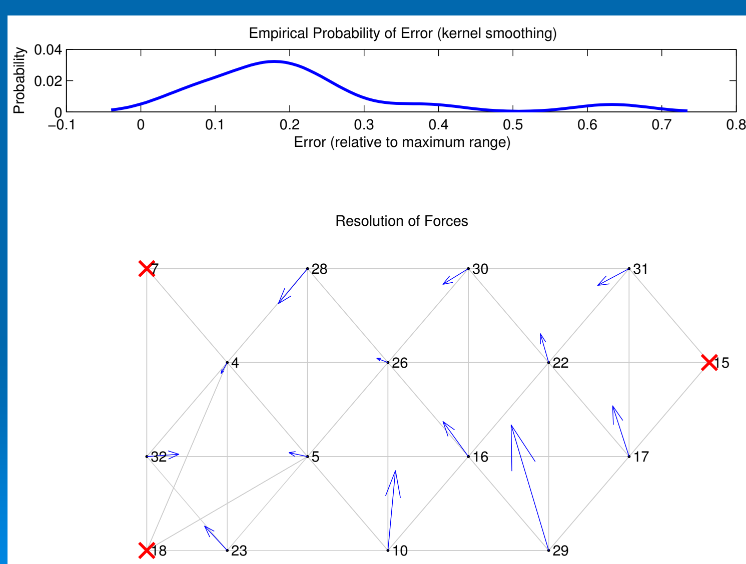
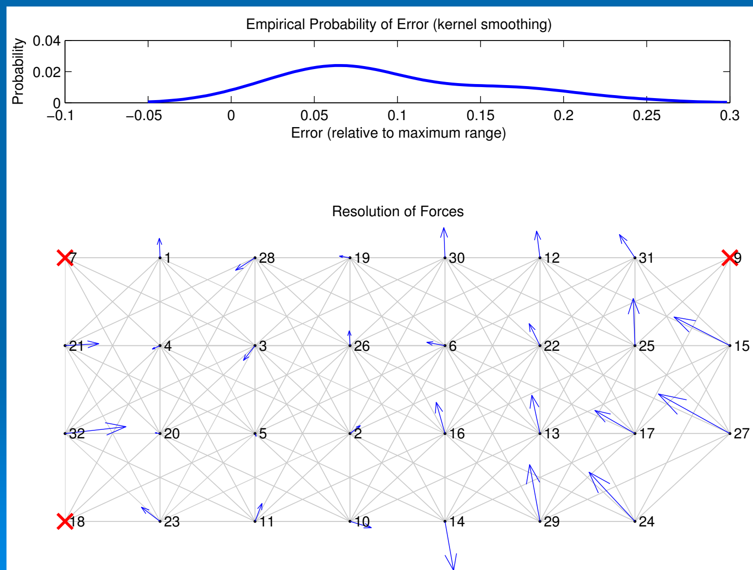


Localization Accuracy



Evaluation

- Node-level Resolution
- Scalable Deployment
- Event-driven
- Simple and Approximate Operation

II. MultiHop Networking

Overview:

•Characteristics of wireless mesh networks

• TinyOS Status of MultiHop Protocols

Ad-Hoc Routing (Self configuring)

• Links are not reliable over the long term

• Links change dynamically

• Requires networking topology that also dynamically changes.

• Low energy requirements limit types of protocols. Powered networks can afford to expend a lot more energy to manage links.

• Broadcasting is energy and time inefficient

• Protocols where the motes dynamcially determine the best parent are attractive.

Mote Msgs Constrain Sleep Time

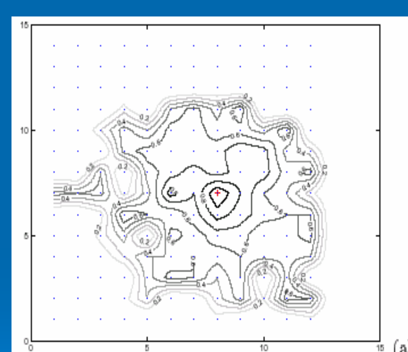
Computation of required sleep time to achieve duty cycle given number of TOS msgs to rcv/xmit while awake

	value	units
Specifications		
Msg Size	40	bytes
Msg Preamble	16	bytes
Baud Rate	38400	baud
Duty Cycle	0.5	%
# of msgs to rcv/re-xmit during wake time	5	msg
Computed Values		
Time to xmit/rcv 1 msg	11.7	msec
Time to rcv/xmit all msgs	116.7	msec
Required sleep time to maintain duty cycle	23.22	sec

Motes closer to base station get more messages

Radio Link Behavior #1

- Radio contour plot shows received radio strength varies significantly .

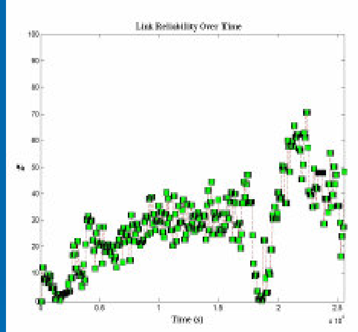


From Alec Woo, To be Published

Radio Link Behavior #2

Static links show variability in receive strength over time

• Local null effects, people, … influence quality of link



(c) Link reliability variations between two immobile nodes over a period of seven hours, with receiver placed at the cell edge of the transmitter.

From Alec Woo, To be Published

Broadcasting (flooding)

•Backward links

•Longs links

•Stragglers (no reception)

•Clustering

•Asymmetric links

Flooding at 19.2K baud Tos Packet, 156 motes

•80msec to receive then transmit

•Each mote transmits once:

-156*40msec = 6.25 sec (no rndm delay)

- Probably ~13 seconds with rndm delay

- Large probability of pckt collision.

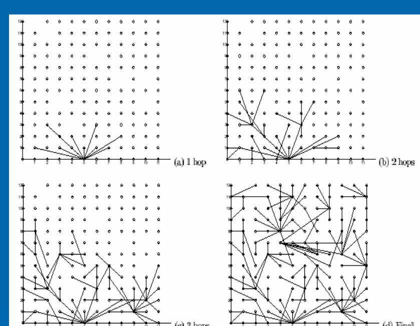


Figure 2: Snapshots from a single run of flooding on the experimental testbed

13x12 grid (156 motes)

An Empirical Study of Epidemic Algorithms in Large Scale Multihop Wireless Networks

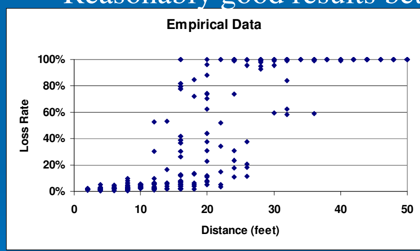
Deepak Ganesan, UCLA; Bhaskar Krishnamachari, Cornell; Alec Woo, UC Berkeley; David Culler, Intel Research and UC Berkeley; Deborah Estrin, UCLA; Stephen Wicker, Cornell.

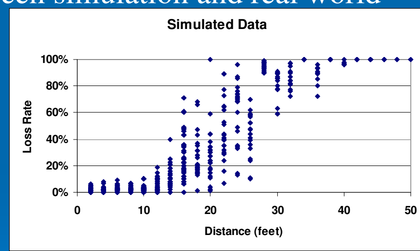
Simulation

• TinyOS supports PC simulation of networks.

• Best way to start, prove out code before real implementation

• Reasonably good results between simulation and real world





TinyOS and Multihop

• Complex routing protocols

• Complex energy management

• Complex time management

• No single multihop stack; application dependant

• TinyOS will allow users to wire in different protocols with minimal effort.

• TinyOS will allow users to compare different protocols for reliability and efficiency.

• Time/Power management is being added to these protocol (3-4 months)

MultiHop Components

- Routing beacon from base station to establish route paths back.
- Find best parent to forward messages:
  - Routing Table: List of best neighbors and routing info. Sram constrained.
  - Table Management: Eviction/Insertion of neighbors into routing table
  - Estimator: Computation of neighbors link quality. Ex: # of hops, sequence numbers. Estimators differentiate strategies.
  - Parent Selection: Decide on parent to forward messages.
  - Cycle Detection: Avoid loops (I.e. forwarding msg to child instead of parent
- Timer : Period update of routing tables, messaging…
- Power management

From Alec Woo, To be Published

MultiHop Components

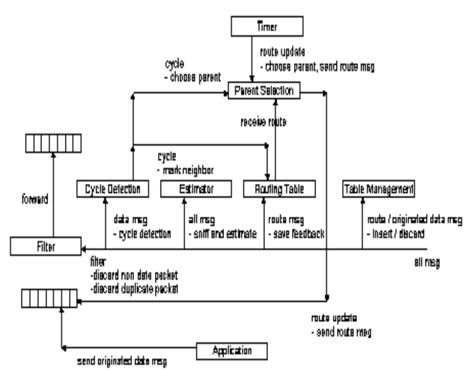
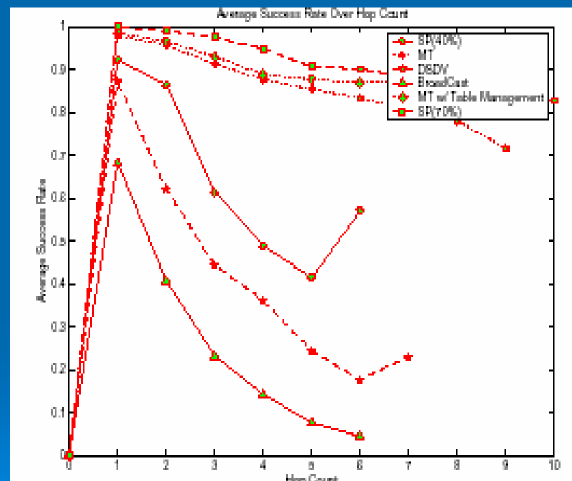


Figure 9: Message flow chart to illustration the different components for routing.

From Alec Woo, To be Published

Multihop Throughput

- Can achieve ~90% packet throughput over 5-6 hops with good protocols.
- Link estimators critical to good multihop. Need to change quickly as link quality changes.



Simulated Results;
From Alec Woo, To be Published

Some TinyOS Multihop Stacks

Protocol	Comments	Status	Pwr Mng	Authors	TinyOS Location
Surge	Used in TnyDB, GSK.	Being replaced by Alec Woos protocol	none	UCB	apps/surge
DSDV	Mote version of standard algorithm. Good results.	Released and stable	**	Intel	contrib/hsn
TinyDiff	Now deployed in James Preserve.	Doesn't support mote base station (1-2 months)	*	UCLA-CENS	contrib/ TinyDiff
Alec Woo	PhD research. A lot of work on estimators. May be best when done.	Should be released in next few months.	***	Alec Woo UCB	Not released yet

* Power management implementation in progress
** May be released with power management
*** Currently using long radio preambles