Rapid Onset Ad Hoc Network

CMPT 464: Wireless Networks and Embedded Systems

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Outline

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Mobile

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Introduction

Locationing In Distributed Ad-Hoc Wireless Sensor Networks

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Date of Conference: May 7-11, 2001 Published by IEEE on Aug 7, 2002

C. Savarese, J. M. Rabaey, and J. Beutel, "Location in distributed ad-hoc wireless sensor networks," , vol. 4, 2037–2040 vol.4, 2001, ISSN: 1520-6149. DOI: 10.1109/ICASSP.2001.940391

Purpose

Why do we want the positions of nodes in an ad hoc network?

- Robot Control
- Virtual Reality
- Deployment
- Military applications

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Navigation

Positioning in Multihop Networks

- Distance Measurements
  - RSSI
  - Angle of arrival (AOA)
  - Time of arrival (TOA)
  - Time-distance of arrival (TDOA)
- Triangulation
  - At least three distance measurements are required to calculate Triangulation.
  - Calculated using a system of linear equations

Challenges

- Triangulation
  - Anchor Nodes
  - TDOA requires high synchronization
  - AOA requires costly antenna arrays
- RSSI
  - Sensitive to multi-path, interference and non-line of sight scenarios

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Triangulation

Range measurements are received from a large amount of neighboring anchor nodes.

Least-mean squares approach is used to solve the triangulation problem.

Results with a 5% range error was achieved.

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Topology Discovery

Topology Discovery is done by using the Assumption Based Coordinates (ABC) algorithm.

- Can return relative, or absolute position.
- Assumes the first node is located at (0,0,0) or GPS determined origin.

$$\mathrm{x2} = \frac{r_{01}^2 + r_{02}^2 + r_{12}^2}{2r_{01}}$$

$$\mathrm{y2} = \sqrt{r_{02}^2 - x_2^2}$$

- Where r is the RSSI determined distance

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Global Positioning

Cooperative Ranging is used to converge nodes to a global solution.

- A global resource is needed.
- Routing bottlenecks and lots of wasted energy

Each node concurrently executes functions.

- Receive distance information from neighboring nodes
- Solve distance problem
- Transmit results to neighboring nodes

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Implementation

In regards to our project, the ABC algorithm can be used for deployment.

You would have to know distance ahead of time.

Compare network distance to actual distance, deploy if % error is within a threshold.

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Signal Strength Based Link Sensing

Associativity Based Routing (ABR)

- Connections are determined to be Stable or Unstable Uses packet tests to check connection
- Changes after detecting lost packets in a row
- Prefrence to stable links when selecting route

Protocol Based Signal Strength

- Connections are determined to be strong or weakly connected
- Uses RSSI comparison to determin a connections strength
- Based on the interval of strong and weak connectivity to determin route

Weaknesses

- Assume there is an exisiting link
- Attempt to avoid link breakage based on signal strength
- Use information to sellect a path with stable links

H. Ali, A. Naimi, A. Busson, and V. Veque, "Signal strength based link sensing for mobile ad-hoc networks,"

Optimized Link State Routing

OLSR

- Uses a partialy fixed network of nodes
- Not suited to a mobile ad-hoc network where link breakage is common
- Connection is unstable after 2 lost pings
- Between missed pings the sent packets are lost

Signal Strength Based Link in OLSR

- Predict link breakage before they occure
- Reward improved or strong signal strength
- Punish weakening or weak signal strength

H. Ali, A. Naimi, A. Busson, and V. Veque, "Signal strength based link sensing for mobile ad-hoc networks," *Telecommunication Systems*, vol. 42, no. 3/4, pp. 201–212, 2009, ISSN: 10184864. DOI: 10.1007/s11235-009-9180-y. [Online]. Available: https://library.macewan.ca/library-search/detailed-view/iih/44917371

Signal Strength Based Link Algorith

Assumptions

- The network will be set up in an open space
- The recived power measurement is delivered by hardware
- Always have a fixed node near a mobile node

Algorithm

- Will use two thresholds for implementing RSSI
  - A low threshold will be used to indicate an unstable connection
  - A high threshold will be used to indicate a stable connection
- The diffrence between packet signal strengths is evaluated to affect the connection
  - If the signal strength from the previous packet and current packet increase it reward the connection
  - If the signal strength from the previous packet and current packet decreases it punishes the connection

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Operational Test

Used multiple set up methods for the ad-hoc network

- Sequential line
- Disperced deployment

After deployment check overall network performace

Use Three test for connectivity of nodes

- Stationary to Stationary
- Stationary to Mobile
- Mobile to Mobile

Conclusions

- Use of both a packet loss and signal strength check made a more robust network
- Use of algorithm improved performace and helps prevent loops in the letwork
- Increased capacity utilization

Relevance to Project

RSSI

- Strengths
  - Able to adjust the signal strength that node disconnects
- Weakness
  - Objects interfere with signal strength

Packet Loss

- Strengths
  - Quick to disconnect a bad node
- Weakness
  - Can lead to less efficent or unstable networks

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Adaptive Transmission Power Control

ATPC

- Developed an algorithm to change transmission power to improve efficiency
- Try and guaranteed a specified link quality
- Was developed to save power and increase the lifetime of nodes

S. Lin, J. Zhang, G. Zhou, L. Gu, J. A. Stankovic, and T. He, "Atpc: Adaptive transmission power control for wireless sensor networks," , SenSys '06, pp. 223–236, 2006. DOI: 10.1145/1182807.1182830. [Online]. Available: http://doi.acm.org/10.1145/1182807.1182830

Deployment and Maintenance

Beacons

- sends beacons for deployment and periodically after
- the beacons are a set of 100, or 20 packets at differing power levels

Model

- nodes then report back to the sending node (record the average RSSI and PRR)
- Using the data reported back they create a model that is used to determine optimal power levels for different nodes

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RSSI and LQI

RSSI and LQI

- RSSI: is a measurement of signal power which is averaged for eight signal periods
- LQI: is a measurement based on the error rate of the first eight symbols

Discoveries

- RSSI and transmission power are linearly related
- There is a strong correlation between RSSI/LQI and TX power

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Discoveries

- using ATPC only 78.8% of the power that a uniform transmission power decide would use
- 3.9% of the packets sent are control packets and they use 1.9% of power
- PRR for ATPC is consistently around 98%
- PRR uniform power level is only at 95% for 25% of the time

S. Lin, J. Zhang, G. Zhou, L. Gu, J. A. Stankovic, and T. He, "Atpc: Adaptive transmission power control for wireless sensor networks," , SenSys '06, pp. 223–236, 2006. DOI: 10.1145/1182807.1182830. [Online]. Available: http://doi.acm.org/10.1145/1182807.1182830

Introduction

- TCP performance in ad hoc networks
- Seek to increase TCP performance in network
- Proposed solution to implement design uses signal strength
- Proposed solution only effective for solving mobility issues
- Simulation results are promising
- UDP not considered

F. Klemm, Z. Ye, S. V. Krishnamurthy, and S. K. Tripathi, "Improving tcp performance in ad hoc networks using signal strength based link management," *Ad Hoc Networks*, vol. 3, no. 2, pp. 175–191, 2005. DOI: 10.1016/j.adhoc.2004.07.005

Crux

- Would introducing a connection characteristic such as signal strength improve a mobile TCP ad hoc networks performance?

F. Klemm, Z. Ye, S. V. Krishnamurthy, and S. K. Tripathi, "Improving tcp performance in ad hoc networks using signal strength based link management," *Ad Hoc Networks*, vol. 3, no. 2, pp. 175–191, 2005. DOI: 10.1016/j.adhoc.2004.07.005

Related Work

- Use of explicit link failure and explicit rout establishment notifications
- Use of fixed RTO
- Introduction of the COPAS protocol
- Route failure prediction
- Pre-emptive routing scheme
- No pervious work salvages transit packets
- Klemms design seeks to solve this

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Packet losses in ad hoc networks

- Node mobility and link layer congestion are the two main reasons for packet losses
- During a situation of congestion false link failures may arise
- Transmission range 250m and interference range of 550m

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Reducing Link Failures

- Mechanism used to reduce packet loss in mobile network is measuring signal strength at the physical layer
- First determine if a link failure due to mobility or congestion
- Coping with false link failures
- Two mechanisms for alleviating the effects of mobility on TCP performance, Proactive and Reactive Link Management
- Modification to the AOBV

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Findings/Disscussion

- Simulation results
- Effects of traffic loaf
- Effects of node mobility
- Higher packet loss due to mobility the better greater the improvement

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Future Work

- The design of smart techniques to estimate the level of congestion in a network
- Correctly determine the levels of congestion of the network

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Relation

- Use of signal strength to determine positive node loss
- Deploying nodes have a relation to signal strength to find optimal deployment location
- Power level management improves packet throughput

F. Klemm, Z. Ye, S. V. Krishnamurthy, and S. K. Tripathi, "Improving tcp performance in ad hoc networks using signal strength based link management," *Ad Hoc Networks*, vol. 3, no. 2, pp. 175–191, 2005. DOI: 10.1016/j.adhoc.2004.07.005

TCP vs ATP Protocol. . .

TCP (Transmission Control Protocol)

- Window based transmissions
- Slow start
- Dependant on ACKs

ATP (Ad Hoc Transport Protocol)

- Rate based transmissions
- Quick start
- Use of SACKs

K. Sundaresan, V. Anantharaman, H.-Y. Hsieh, and R. Sivakumar, "Atp: A reliable transport protocol for ad-hoc networks," *MobiHoc03*, pp. 64–68, 2003. [Online]. Available: https://www.sigmobile.org/mobihoc/2003/papers/p64-sundaresan.pdf

Window Based vs Rate BAsed Transmissions

TCP

- Control data transmission by adjusting the congestion window size based on the ACK's received
- Send two packets for each ACK received
  - Additive Increase, Multiplicative Decrease
  - Leads to burstiness of data

ATP

- Rate-based mechanisms control the transmission rate based on the measurement taken at the end host
- No burstiness
- ACK bunching happens
  - Several acks received at the same time
  - Leads to flooding of network with window based transmissions

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Slow vs. Quick Start

TCP

- Starts off slow, and gradually increases
- Probes the network for available bandwidth
- May take a while to get to true available bandwidth
- Loss occurs? return to slow start phase

ATP

- Starts off quickly and may decrease
  - Packet loss is more frequent so a connection may spend most of its life in the slow-start phase if using TCP

K. Sundaresan, V. Anantharaman, H.-Y. Hsieh, and R. Sivakumar, "Atp: A reliable transport protocol for ad-hoc networks," *MobiHoc03*, pp. 64–68, 2003. [Online]. Available: `https://www.sigmobile.org/mobihoc/2003/papers/p64-sundaresan.pdf`

Decoupling of Congestion Control and Reliability

In TCP, congestion control and reliability are tightly coupled through dependence on ACK arrival

With ATP you have. . .

- Feedback about the strength of the connection is piggybacked onto packets being routed to their destination
- Selective ACK's used to report losses of connections, or holes, in the data stream
  - According to RFC 2018, a selective ACK, or SACK, is sent to inform a sender about all segments that have arrived successfully.

K. Sundaresan, V. Anantharaman, H.-Y. Hsieh, and R. Sivakumar, "Atp: A reliable transport protocol for ad-hoc networks," *MobiHoc03*, pp. 64–68, 2003. [Online]. Available: `https://www.sigmobile.org/mobihoc/2003/papers/p64-sundaresan.pdf`

In Relation to Our Implementation

We also piggyback statistical information about the strength of the connection on each message sent to the sink

For future work, SACK's could be used exclusively in our network

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Deployment

1. On startup, a node begins listening for a deployment broadcast
2. The sink node has the option to begin broadcasting the deployment message (300ms)
   - The maximum number of nodes and deployment type are held in the deployment packet
3. A new node is turned on as is moves away from the broadcasting node, it runs the specified deployment test
4. The node then sends the stop signal once deployed and begins deploying if it is not the last node
5. If the node is the final node, it will send the stop signal and begin transmitting data to the sink node(250ms)

Deployment tests

RSSI test

- Records how many of the previous 16 packets were below the RSSI threshold
- Compares the number of low RSSI values to a threshold (10)

Packet Loss test

- Records how many of the previous 15 packets were lost, based on sequence number
- Compares the number of lost packets to a threshold (4)

Data Consistency

- Messages wait for an ACK before sending the next message when streaming data
- PINGs and PONGs
- An acknowledgment is also used to signal that the STOP signal has been received
- Information about total packet loss is relayed with the packet at each hop

Future Work

Decrease the delay for stream packets

- Currently 300ms

Improve RSSI

- More research
- Introduce high and low thresholds

Recovery on lost pings & pongs

Implement specific node behaviour

- Stream
- Status

Conclusions

Questions?

Thank you!