

## QoS Support for 3D indoor multiple hop wireless networks design detail

The main components in our QoS support for indoor multiple hop wireless networks design:

- Topology generation
- Mobility prediction
- Location service
- Probing and Soft resource reservation
- QoS routing
- Admission control

System parameters:

Number of nodes: 40~50

Topology: 500x500/670x670/1500x300/...

Node density

Node distribution: uniform/...

Transmission range: 250m

Antenna: omni

Energy:

Mobility model: random/random waypoint/group/predefined

Traffic: CBR/TCP

QoS parameters (defined below)

QoS parameteres:

First, we need to define the specific QoS parameters for each application that needs QoS support.

The following information could be included in the QoS requests:

srcID, dstID, flowID, QoS parameters (fixed/adaptive/dynamic/range) {bw, delay, duration, loss rate, estimated duration, jitter, ...}

flowID is used to identify the specific QoS request. It does not need to be connection oriented. Intermediate nodes will use flowID to differentiate traffics with different QoS requirements.

The desired QoS support may include: min BW/max delay/max loss rate/max jitter/...

Multiple constraints could make QoS routing too complicated, and even intractable. Most of time, we use single constraint. For multiple constraints, sequential filtering technique will be used. Even for single constraint, such as delay constraint, it still could be a NPC problem. Other techniques or assumptions, such as fluid model, will be used to simplify problem.

Node metrics

<location, range, stability, speed, mobility profile, power, residual bw, queuing delay, propagation delay, transmission rate, service discipline, neighbor status>

Rate control to limit best effort traffic (fairness, avoid greedy)

Dynamic Residual bandwidth

Stability Rank of nodes (mobility ratio=move time/total time)

In order to make delay based QoS requirements feasible, fixed service rate may be desirable. Transmission delay fixed, queue delay depends on bucket size and application data rate. Higher-level admission control maybe required to control application data rate.

End-to-end behavior: fluid model, the delivered queuing delays do not exceed the fluid delay by more than the specified error bounds. Weighted Fair Queue and Virtual Clock are approximations of fluid model. (rfc2212)

Flow QoS requirements have to be mapped onto path metrics, which includes node metrics and link metrics.

### Topology generation

There are some scenes in ns2 we can borrow. However, there are only limited amount of topologies. It is desirable to use other topology generators to generate more topology for our need. The resource we can use: ...

### Mobility model

Random waypoint and group mobility models are included in ns2. However, we may still need to change them, or generate our own mobility profile, or use pre-defined mobility model, to support the prediction of nodes' future location, i.e. to get the polynomial coefficient.

### Location service:

Used by the sender or any other node to determine the destination node position and other nodes' position. Location service falls in one of the following four categories: some-for-some, some-for-all, all-for-some, all-for-all. Or, it can be classified as: Centralized/distributed. Dedicated location server may be used.

Normally, if we use location based routing, the destination node position is contained in the header of the packet.

GPS based

GPS free: GLS, 3D based-location service

Location service can provide nodes' location, topology information, global state information, and so on.

Location service does not carry data packets, i.e, does not forward data packets

The traffic between normal nodes and location service should be as few as possible.

Every node is required to report to location service

1. node initiated (push)
  - a) initial registration
  - b) as long as it moves
  - c) when it moves and carry active flow (state information required)
  - d) periodically update

2. requested by location service (pull)

Timer or threshold value is required to keep information up-to-date without incurring too much traffic overhead.

The reported information includes, but not limited to:

Location, mobility profile, link state...

Even QoS routing related metrics, such as residual bw, could be reported to location service to boost QoS routing, as long as the overhead could be controlled under certain threshold. By doing this, we increased the functionality of location service.

Every node can query location service to retrieve required information.

Based on the information it gets from location service, plus the information it has, the node could construct the network topology, compute QoS path, generate routing table...

We assume such location service exists in our environment. One possible solution is that, because it is 3D indoor wireless networks, we have a couple of fixed wireless nodes, called dedicated location servers with well known address, which cover the whole indoor area and can communicate with each other through themselves.

#### Routing

Shortest path: optimized for a single arbitrary metric, administration weight or hop count.

Link state: path selection algorithm, link cost function, link state update policy (periodical or triggered)

Geography routing

#### Geography routing (location based routing)

Path selection: basically just a search technique. We need resource constraint path selection to support QoS.

Forwarding strategy:

Greedy forwarding

Most forward within r

Nearest with forward progress

Closest to the straight line

Restricted directional flooding

Hierarchy forwarding

Recovery strategy if forward fails

Least backward progress...

#### QoS routing

Dynamic determine feasible paths with optimization of resource usage and graceful performance degradation.

Resource constraint shortest path (k-shortest paths) or geography routing algorithms.

More than one routing metrics could be distributed. Traditional opportunistic routing (such as SPF) may shift traffic to better path and cause routing oscillation. QoS routing should not do that. Alternate routing and pruning infeasible links are preferred by QoS routing.

Flow QoS requirements have to be mapped onto path metrics.

Path metrics: link metrics and node metrics

Adaptive QoS Routing:

1. measuring and gathering network state information
2. computing routes based on available information

A practical approach is that treats the routing of each flow independently of the routing of other flows.

Many issues:

- what state information is used
- whether local or global state is used
- what triggers the propagation of state information
- whether routes are computed in a distributed or centralized manner
- whether routes are computed on-demand, pre-computed, or in a hybrid manner
- what optimization criteria, if any, are used in computing routes
- whether source routing or hop by hop routing is used, and
- how alternate route choices are explored

Probing and Soft Resource Reservation

Soft reservation

Timeout after a certain amount of time

Implicit or explicit tear down

Probing

Limited directional flooding

Ticket-based flooding

Location-based reservation

Location-based reservation (My idea, will be explained in more detail)

Resource is not just reserved at certain nodes along the QoS path, but “virtually” reserved at the physical area along the QoS path between source and destination. If a node with resource reserved moves out of the QoS path, it could transfer the resource reservation information to other nodes nearby, which could keep the QoS path continuously valid and keep the QoS traffic going.

Ticket-based flooding

Refer paper

Dynamic link support, i.e. dynamically maintain QoS path

When intermediate node moves out of the src-dst path, it (or its neighbors) can notify src/dst, and appropriate intermediate node can move in to keep the continuity of QoS traffic.

Admission control

Cac calculation

Metrics:

Efficiency and effectiveness

QoS successful rate vs prediction accuracy

Delays

Residual capacity

Overhead (computation/storage/communication)

Average path cost

Mobility ratio (refer chen paper)

Sequential filtering (rfc2386)

Notes:

Imprecision model refer to chen JSAC

Topo change: probability distribution function/variation/weighted average

Multiple service classes: router and link resources may be logically partitioned among various service classes.

Issues:

Current Ns2 code only supports 2D location simulation, although it is expandable to 3D.

Ns2 geography routing code

Terms:

MRP: most reliable path (refer Orda inaccurate info JSAC 99)

Taxonomy:

State	vs	stateless
Centralized	vs	decentralized (distributed)
Resource reservation	vs	diffserv
Local state	vs	global state
Hard QoS	vs	soft QoS
Accurate information	vs	imprecise information
Certain parameters	vs	uncertain parameters
Infrastructure	vs	infrastructureless
Gps based	vs	gps free
Connection oriented	vs	connectionless
Dynamic	vs	static
Mobile ad hoc networks	vs	static ad hoc networks
Proactive	vs	reactive
(Proactive: maintain routing information about available paths even not currently used. Reactive: route discovery before packets exchange, longer delay for the first packet.)		
Shortest path	vs	geography

## QoS Support for Indoor Wireless Networks Design Detail

Broadcasting vs geocasting

Flow admission control vs higher-level admission control

(FAC: whether a node or a link has sufficient resources)