Improving Resource Consumption for Epidemic Routing in Intermittent Networks

Presented By-

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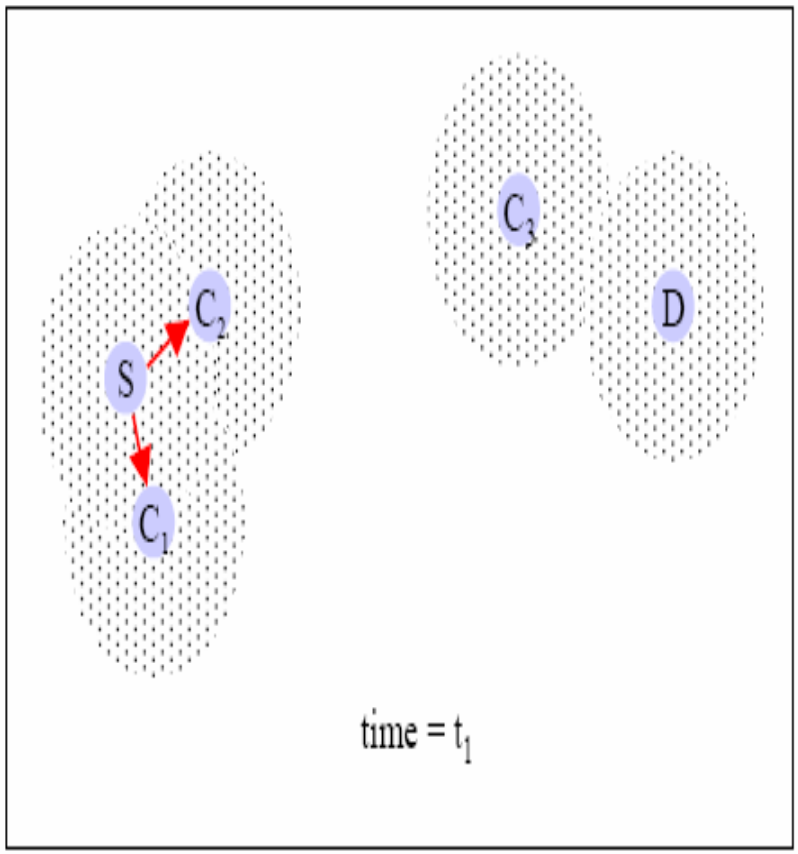
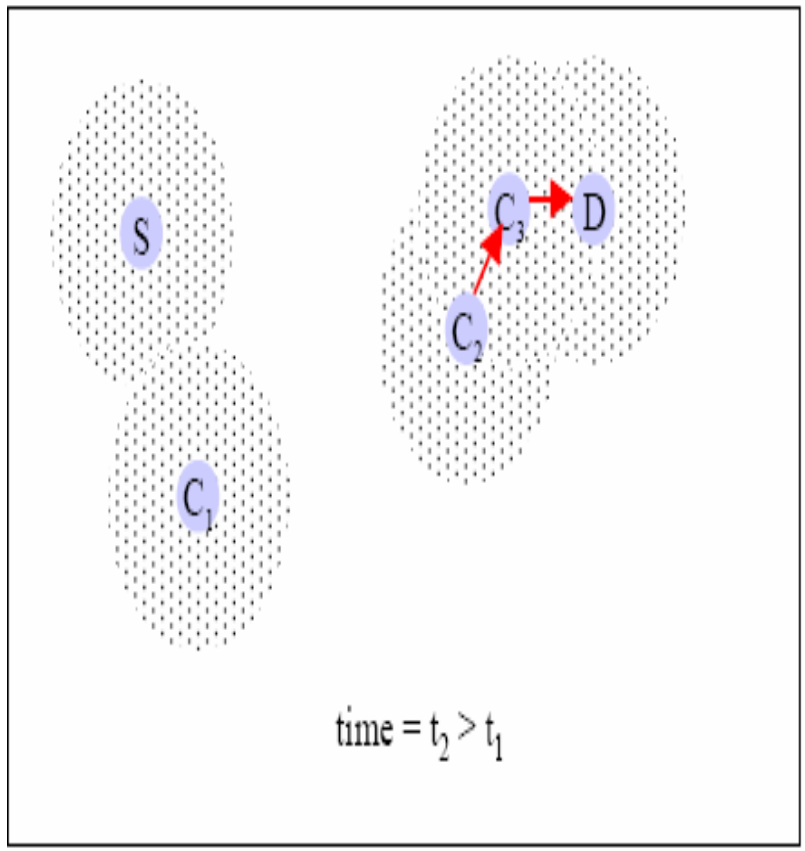
Primary Reference:

Melissa Ho, Stephen Hailes, Vladimir Dyo, Damir Pavušin, and Jasper Weener, “Improving Resource Consumption for Epidemic Routing in Intermittent Networks”

Epidemic Protocol





Protocol Improvements
Xtended Epidemic Routing (XEPI)

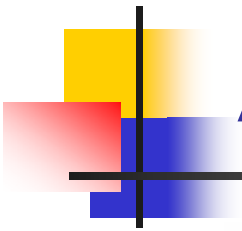
- Usage of ACKs and Garbage collection
- ACKs exchanged prior to message exchange
- Each node prunes delivered messages prior to sending summary vectors
- Broadcasts in the medium instead of unicast

Protocol Improvements
XEPI with Counters (XEPI-C)

- Counter based technique to avoid potential broadcast storms
- Assumption
  - If Node has heard a particular message recently, likely that most of its current neighbors would have overheard it.
  - Wait for more neighbors to appear
  - Do not drop, suspend transmission for some time

Protocol Improvements
XEPI with History (XEPI-H)

- Queue discipline used for the message buffers to give higher priority for messages a given node is likely to deliver
- Higher priority for messages destined to nodes it has seen more frequently
- Discards the message destined for the node with the lowest contact frequency



Algorithm

XEPI-1. [EPI-1] Host A detects a new host, and initiates an anti-entropy session with Host B, provided that it has not previously contacted host B within a configurable time period.

XEPI-2. Host A transmits its ACKs one by one to Host B.

XEPI-3. Host B transmits its ACKs one by one to Host A.

XEPI-4. Host A and Host B each update their ACK buffers, and garbage-collect newly acknowledged messages from the message buffer.

Algorithm

XEPI-5. [EPI-2] Host A transmits its updated summary vector (S_A) to Host B, telling it what messages it is currently buffering.

XEPI-6. [EPI-3] Host B determines which messages Host A is buffering that it does not already have ($S_A \cap \neg S_B$), and requests these messages from A.

XEPI-7. [EPI-4, modified] Host A broadcasts the requested messages to any available neighbor.

XEPI-8. [EPI-5] Host B receives the messages, discarding old ones from its buffer according to the current management policy (FIFO) if it is full.

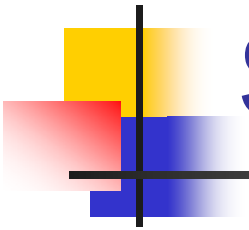
Algorithm

XEPI-9. [EPI-6] Host B transmits its updated summary vector (S_B) to Host A, telling it what messages it is currently buffering.

XEPI-10. [EPI-7] Host A determines which messages Host B is buffering that it does not already have ($S_B \cap \neg S_A$), and requests these messages from B.

XEPI-11. [EPI-8, modified] Host B broadcasts the requested messages to any available neighbor.

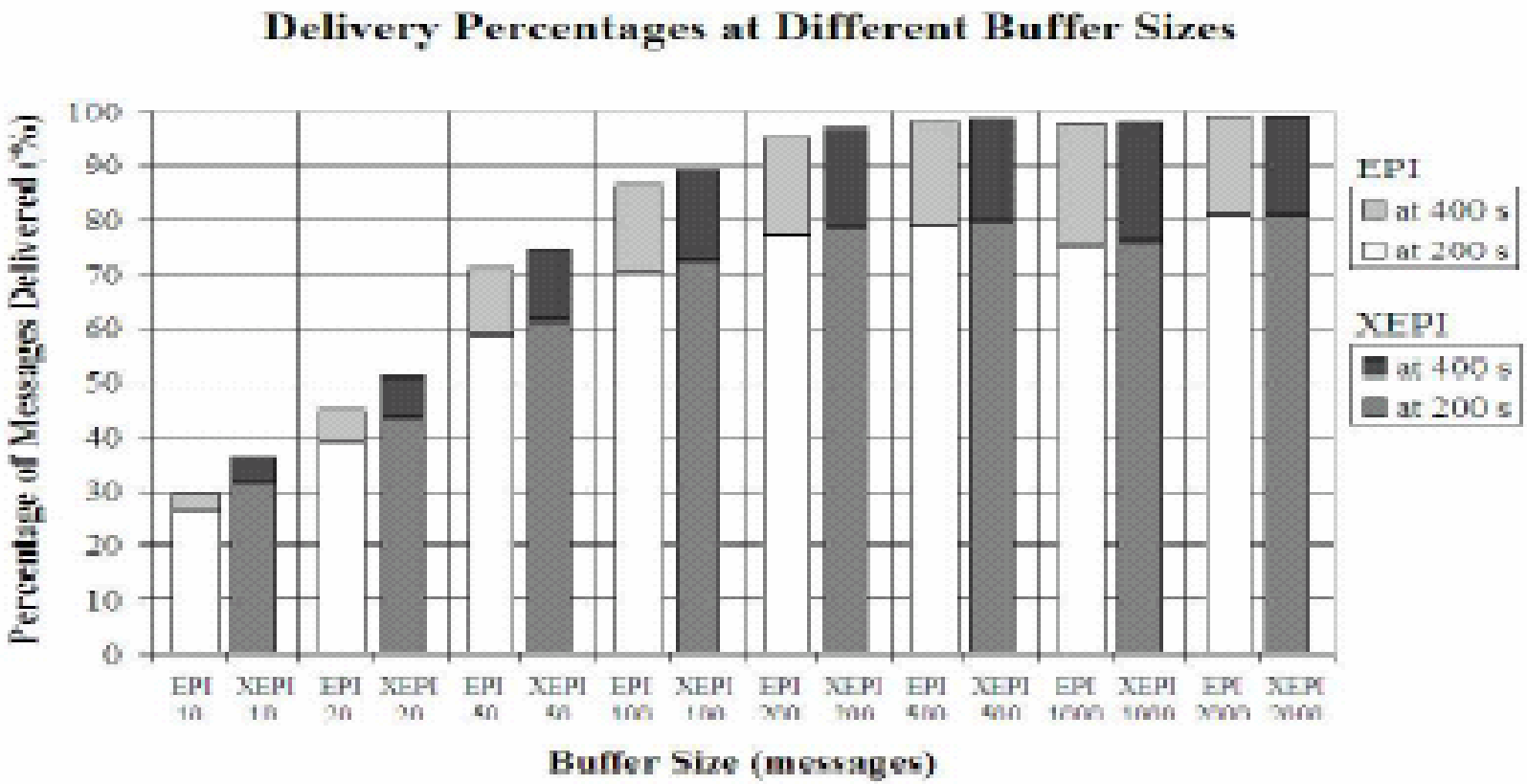
XEPI-12. [EPI-9] Host A receives the messages, discarding old ones from its buffer according to the current management policy (FIFO) if it is full.



Simulations

- Random Waypoint Model
  - 50 mobile nodes in a 1500 X 300m in size
  - 45 nodes send messages to 44 other nodes
  - 1980 1 KB messages in 1980 second
- Multi Model
  - 60 nodes divided into 3 groups of 20 nodes each
  - Inter-group communication must occur via the 3rd set of nodes
  - 1980 messages passed amoung them.

Results
Effect of Acknowledgements on Buffer Utilization 1



Results
Effect of Acknowledgements on Buffer Utilization 2

	EPI		XEPI	
Buffer Size	Delivery Rate	Average Latency	Delivery Rate	Average Latency
10	35.9%	307.1 s	42.8%	266.2 s
20	53.4%	297.8 s	60.5%	276.1 s
50	79.5%	246.9 s	83.7%	239.4 s
100	93.1%	201.3 s	95.7%	195.0 s
200	98.9%	160.1 s	99.5%	150.1 s
500	100.0%	144.8 s	100.0%	139.8 s
1000	100.0%	151.5 s	100.0%	148.4 s
2000	100.0%	134.4 s	100.0%	134.9 s

Table 1: Comparison of delivery rates and latencies for EPI and XEPI at different buffer sizes in *randway*

Results
Effect of Acknowledgements on Buffer Utilization 3

Buffer Space		10		20		50		100		200		500		1000		2000	
Protocol		EPI	XEPI	EPI	XEPI	EPI	XEPI	EPI	XEPI	EPI	XEPI	EPI	XEPI	EPI	XEPI	EPI	XEPI
Dead	Messages not in Network	1667.7	1749.3	1475.7	1658.7	1141.7	1415.0	750.0	1125.7	402.0	745.0	58.7	203.3	1.0	71.3	0.0	0.0
	Buffer Slots Occupied	2.6	2.7	3.4	3.4	5.2	5.0	7.0	6.8	9.5	9.0	12.3	9.4	n/a	3.8	n/a	n/a
	Lifetime (s)	175.4	254.1	268.0	373.6	440.4	532.6	629.4	690.9	876.6	868.2	1480.2	1182.5	n/a	943.7	n/a	n/a
Live	Messages still in Network	312.3	230.7	504.3	321.3	838.3	565.0	1230.0	954.3	1578.0	1235.0	1921.3	1776.7	1979.0	1908.7	1980.0	1980.0
	Buffer Slots Occupied	2.4	2.0	2.8	3.0	3.9	4.7	5.3	6.5	8.2	9.5	16.1	17.0	28.4	28.9	47.0	44.5

Table 2: Buffer utilization characteristics of EPI and XEPI at different buffer sizes with 50 m transmission range and maximum hop count of 4 hops in *randway*

Results
Effect of Acknowledgements on Buffer Utilization 4

Buffer Size	Average ACKs sent	Average Bytes Sent	Average Garbage Collections	Bytes Garbage Collected	Bytes Collected per Bytes Sent
10	30.8	862.4	0.9	921.6	107%
20	39.6	1108.8	1.5	1536.0	139%
50	48.6	1360.8	3.3	3379.2	248%
100	52.0	1456.0	5.7	5836.8	401%
200	51.0	1428.0	9.3	9523.2	667%
500	49.1	1374.8	14.0	14336.0	1043%
1000	49.8	1394.4	15.9	16281.6	1168%
2000	50.3	1408.4	17.0	17408.0	1236%

Table 3: Resource consumption characteristics of ACKs per message in XEPI using *randway* at different buffer sizes

Results
Reducing Broadcasts using counters

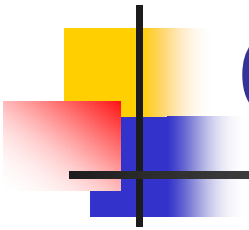
Protocol		EPI	XEPI	XEPI-C
Delivery Rate		79.5%	83.7%	84.4%
Average Latency (s)		246.9	239.4	232.8
Average Hops		3.4	3.4	3.4
Buffer Utilization	Dead	1141.7	1415.0	1493.3
	Buffers	5.2	5.0	5.0
	Lifetime (s)	440.4	532.6	536.1
	Live	838.3	565.0	486.7
	Buffers	3.9	4.7	5.0
ACK Statistics	ACKs per message	n/a	48.6	67.7
	Garbage Collections per message		3.3	3.7
	Garbage Collections per node		129.2	147.0
	ACKs forwarded		113637.7	172945.3

Table 4: Comparison of EPI, XEPI, and XEPI-C in *randway* with a buffer size of 50, 50 m transmission range, and a maximum hop count of 4

Results
Effects of Queuing Discipline on Message delivery

Protocol		EPI	XEPI	XEPI-C	XEPI-H
Delivery Rate		62.1%	65.4%	65.8%	42.1%
Average Latency (s)		154.0	182.5	186.4	117.7
Average Hops		3.1	3.1	3.1	2.9
Buffer Utilization	Dead	1037.0	1143.0	1140.7	1143.3
	Buffers	9.6	8.5	8.2	2.7
	Lifetime (s)	280.6	386.9	397.4	69.1
	Live	943.0	837.0	839.3	836.7
	Buffers	4.4	4.6	4.5	4.3
ACK Statistics	ACKs per message	n/a	37.5	50.1	33.6
	Garbage Collections per message		5.4	6.2	2.8
	Garbage Collections per node		179.0	204.1	91.3
	ACKs forwarded		83784.3	119738.0	77633.7

Table 5: Comparison of EPI, XEPI, XEPI-C, and XEPI-H in *multi* with a buffer size of 50, 50 m transmission range, and a maximum hop count of 4



Conclusions

- Three Mechanisms to improve the epidemic protocol
  - ACKs : Reclaim the buffer space of the delivered messages
  - Counter based Broadcast Optimizations
  - History information used in the Queue messages in the buffer