Splash: Fast Data Dissemination with Constructive Interference in Wireless Sensor Networks

Manjunath Doddavenkatappa, Chan Mun Choon and Ben Leong National University of Singapore







A Fundamental Service: Data/Program Dissemination

A dissemination protocol is required throughout the life of a sensor application

Dissemination completion time is critical

Completion time for existing protocols is still in the order of minutes

Culprit is Contention Resolution

SPLASH

Eliminate the need for contention

Constructive Interference [Glossy'2011]

Channel Diversity [PIP'2010]



Press escape to exit animation and then move on to the next slide









Cycle 3
Transmitting Receiving Oldling

Cycle 4

SPLASH





Constructive Interference is not Scalable [Wang et al. INFOCOM'12]

• The problem is more severe in practice

Constructive Interference is not Scalable



Effect of the Capture Effect



Splash: Transmission Density Diversity

First round: only non-leaf nodes forward

- Typically, more than 50% of the nodes in a tree are leaf nodes [Manjunath et al. RTSS'11]
- Nodes benefit from low transmission density

Second round: all nodes transmit

 Nodes benefit from high transmission density by exploiting capture effect or sender diversity [Rahul et al. SIGCOMM'10]

















Round 2



Splash: XOR Coding

 After two rounds, more than 50% of nodes received most but not full object

Third round: every transmission is a XOR sum

Probability that a packet transmission is useful is increased

Splash: Summary of Its Three Dissemination Rounds

Three Rounds of Dissemination

Transmission Density Diversity Opportunistic Overhearing Channel Cycling XOR Coding

A node in Splash has six chances to receive a packet on up to six different channels

Splash: Local Recovery

If any missing data is recovered locally

 Neighbor querying and data downloading over CSMA/CA

• Fact that about 90% of nodes have the full object makes local recovery practical





Indriya Testbed 139 TelosB nodes



Twist Testbed 90 Tmotesky nodes

Experimental Setup



Comparison

Summary of Results on Indriya (32 KB dissemination)

		Splash						DelugeT2	
Tree [no.]	Size [hops]	R1 [%]	R2 [%]	R3 [%]	N _{R3-100%} [%]	R _{lr} [%]	T _{Splash} [sec]	T _{DelugeT2+CTP} [sec]	T _{DelugeT2GI} [sec]
1	5	84.54	97.23	98.47	91.30	100	22.49	1300	924
2	6	86.52	96.91	98.58	92.03	100	22.61	286	160
3	7	76.68	94.62	97.80	86.23	/21	3.18	/12	286
4	7	88.02	96.12	97.78	92.75		23.74		158
5	9	76.97	93.65	96.69	81.88	- JO	23.85	649	180
6	7	76.73	95.27	98.16	89.86	10	2. 98	610	160
7	7	80.75	93.51	96.98	25.	15s	26.2	365	379
8	7	83.57	94.43	96.01	87.68	0	25.00		2050
9	5	82.46	95.26	97.47	85.51	100	28.05	245 0/6	2022
10	8	84.28	94.92	96.70	86.23	100	. 8.39	550	16
Average		82.05	95.19	97.46	88.26	100	25.15	524	305.3

Summary of Results on Twist (Splash: 32 KB, Deluge: 2KB)

			Deluge					
Tree [no.]	Size [hops]	R1 [%]	R2 [%]	R3 [%]	N _{R3-100%} [%]	R _{lr} [%]	T _{Splash} (32KB) [sec]	T _{Deluge} (2KB) [sec]
1	4	90.58	97.09	99.22	94.38	100	20.07	356.60
2	4	81.08	94.70	99.31	92.13	100	20.19	431.48
3	4	86.53	96.19	98.00	91.01	100	22.79	351.67
4	4	78.64	94.10	98.12	84.09	100	23.37	518.19
5	4	81.42	93.95	97.98	89.89	100	23.41	467.00
6	4	78.04	93.55	96.82	85.39	100	26.66	439.81
7	4	83.90	95.18	97.54	89.	24.73	s 26.79	345.28
8	4	83.70	93.64	96.45	84.27	100	27.32	190
9	6	81.58	93.35	97.02	85.39	100	27.45 4	105
10	5	80.78	93.09	97.11	85.39	100	79.25	97.59
Average		82.62	94.48	97.76	88.18	100	24.73	418.04

Comparison to Other Approaches (Baseline: DelugeT2)

Protocol	No. of nodes	File size [KB]	Reduction factor
MNP (2005)	100	5	1.21
MC-Deluge (2005)	25	24.3	1.6
Rateless Deluge (2008)	20	0.7	1.47
ReXOR (2011)	16	4	1.53
ECD (2011)	25	10	1.44
MT-Deluge (2011)	20	0.7	2.42
Splash	139	32	21

Evaluation of Individual Techniques



Evaluation of Individual Techniques

XOR Coding: increases percentage of nodes having the full object from 37% to 88%

Opportunistic overhearing: decreases dissemination time by 26%

Evaluation of Individual Techniques

Channel Cycling: decreases dissemination time by 25%

Transmission Density Diversity: 39% and 18% of nodes benefit from low and high transmission densities respectively

Local Recovery

completion time local recovery — 3 rounds time —



Local Recovery



Conclusion

- We designed and implemented Splash, a fast data dissemination protocol
- Key factors are constructive interference, channel diversity and techniques for reliability
- Splash reduces completion time by an order of magnitude

Thank you



References

Some of the images in these slides are downloaded from Google Images and Kalyan Varma's website<u>http://kalyanvarma.net/</u>