Managing wireless sensor networks

J. Shim, D. Lim, D. Jeon, T. Simunic Rosing (CSE-UCSD), T. Javidi (ECE-UCSD)
H-W. Braun (SDSC-UCSD), F. Vernon (IGPP-UCSD), P. Bryant (SDSU)
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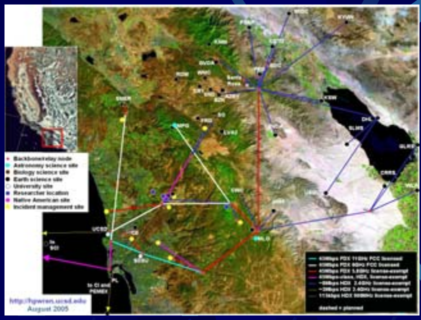


Wireless Sensor Network

Data Acquisition Network Issues

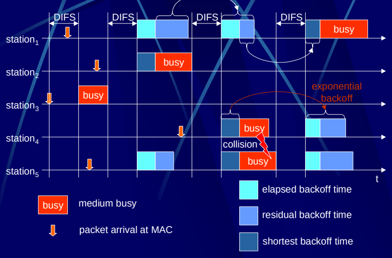
- Data acquisition (sensor nodes)
  - Communication: QoS, bandwidth
  - Battery limitation – maximize lifetime
  - Computing and storage – limited amount of data preprocessing and storage possible
- Data collection (Network & Storage)
  - Load balancing
  - Preprocessing
  - Traffic Priorities
  - Congestion

Initial Project Test bed: Santa Margarita Ecological Reserve

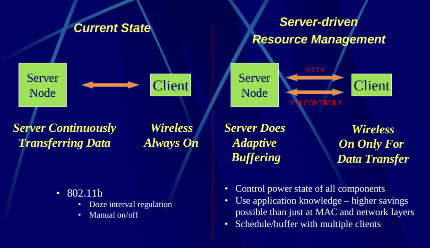
Data Distribution Network Issues (Backbone wireless network)

- Different types of traffic present
  - Sensor node data
  - WWW, Telnet, etc.
- Various link qualities
  - Ranging from fast speed to slow speed
- PBR and QoS
- Congestion
- Reliability

802.11 - contention



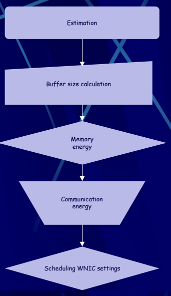
Distributed Resource Management



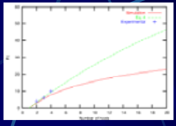
- 802.11b
  - Doze interval regulation
  - Manual on/off

- Control power state of all components
- Use application knowledge – higher savings possible than just at MAC and network layers
- Schedule/buffer with multiple clients

Server RM algorithm



Proportion of collisions in WLAN

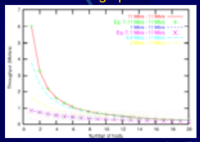


Improve by Scheduling Bursts of IP Packets

Contending traffic

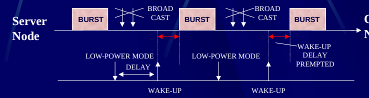
- Longer delay
- Lower throughput
- Higher power consumption

Throughput

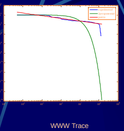


Resource Management Overview

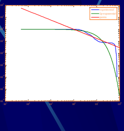
- Each server node schedules data delivery to clients
  - Enable/disable available resource management settings (e.g. 802.11PM)
  - Adjust resource management parameters (e.g. delay until next burst)
  - Perform traffic reshaping
- Exploits knowledge of workload
  - Efficient transmission scheduling in multiple client environment
  - Better quality of service (e.g. delay, throughput)
  - Longer client battery life

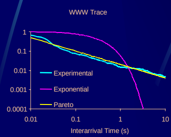


Traffic Characterization



Two different sensor nodes





Distributions

$Exp = 1 - e^{-\lambda_s t}$

$Pareto = 1 - b \cdot t^{-a}$

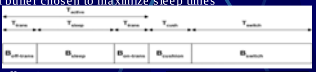
Queue	Distribution
Queue > 0	Exponential
Queue = 0	Pareto

Estimation and buffer sizing process

- Maximum likelihood estimator keeps track of changes in WNIC throughput and data usage patterns

$$\ln(p_{\max}) = (n_{pts} - n_{chng} + 1)\ln\frac{\lambda_{new}}{\lambda_{old}} - (\lambda_{new} - \lambda_{old})\sum_{j=n_{chng}}^{n_{pts}} \Delta t_j$$

- Size of buffer chosen to maximize sleep times



- Total buffer size:
- Buffer region actively involved in data transfer in steady state:
- Buffer size required during interface switch:
- Average sleep time:

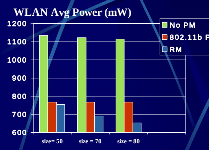
$$B = B_{active} + B_{switch} + B_{cush}$$

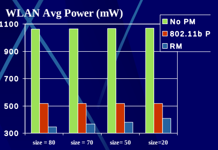
$$B_{active} = B_{sleep} + B_{on-trans} + B_{off-trans}$$

$$B_{switch} = T_{switch}\ \lambda_u$$

$$T_{sleep} = \frac{B_{sleep}(\lambda_t - \lambda_u)}{\lambda_t \lambda_u}$$

Server RM with Video Streaming





- 30 frame/sec to a mobile
- 40% of power reduction
- 15 frame/sec to a mobile
- 65% of power reduction
- larger number of concurrent clients with real time playback

Multiple client scheduling

- WLAN has 6 video clients, 6 audio clients, 10 WWW clients and 4 email clients
- Improved EDF and RM (IEDF, IRM) show savings in performance and power consumption over other classical scheduling algorithms
- All scheduling algorithms save minimum an order of magintude in power as compared to not using any scheduling algorithms

802.11b — Average power dissipation (mW)

App.	IEDF	EDF	IRM	RM	RRQ	WFQ
	Scheduling algorithms					
MPEG4	35	46.5	34.7	41.8	40.2	41
Email	2.3	2.1	2.4	3.7	3.1	3.7
MP3	43.5	54.5	43.3	43.1	49.2	50
WWW	14.7	17.7	14.4	21	17.9	21

802.11b — Average time delayed (sec)

Apps.	IEDF	EDF	IRM	RM	RRQ	WFQ
	Scheduling algorithms					
MPEG4	19	209	16	132	51	284
Email	4	0	9	27	13	33
MP3	6	190	2	0	83	272
WWW	16	63	14	113	61	174

Future work

- Derive theoretical bounds for bandwidth improvement due data burst scheduling
- Include traffic priorities
- Implement preprocessing on nodes starting with seismic monitors
- Study interaction between scheduling and routing policies for QoS

For more information see:
- http://hpwren.ucsd.edu
- http://www.cse.ucsd.edu/~trosing/
- http://fleece.ucsd.edu/~tjavidi/