TEMPEST: Test EnvironMent for Performance Evaluation of the Scheduling of packeTs

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Talk overview

Problem

what

to easily evaluate packet scheduling solutions

- execution time
- QoS guarantees
- throughput

why

emerging fields need packet scheduling

- 3G/4G, LTE, Emergency Networks
- Technologies QoS driven

how

TEMPEST

State of the Art

typical solution

simulated environment vs emulated environments

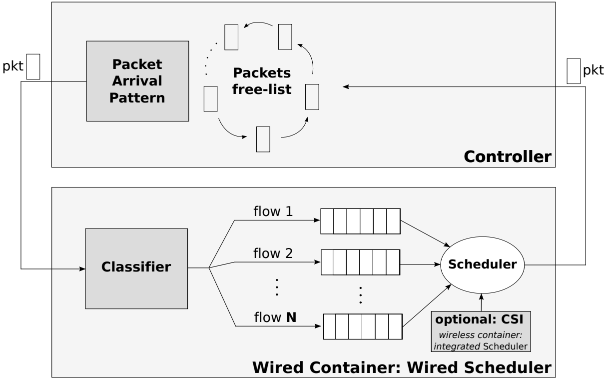
weaknesses

- simulators
  - **easy** to set up a suitable test environment
  - **hard** to import/export real code
  - time is simulated!
- emulators
  - **hard** to set up a suitable test environment
  - **easy** to import/export real code
  - packet generation, reception, device drivers and other costs dominate the measurements;

TEMPEST

Test EnvironMent for Performance Evaluation of the Scheduling of packeTs

UNIX-based open tool able to measure the *actual performance* of a packet scheduler under the desired operating conditions

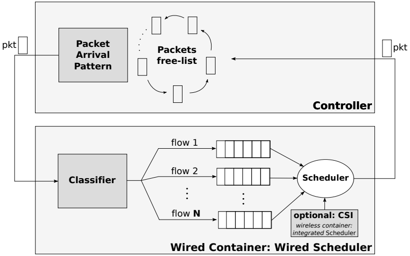


TEMPEST modules 1/3: The Controller

TEMPEST Controller

simulates the desired realistic packet arrival pattern

- manages a free list of fake packets
- uses fake packets to reduce the system overhead (40Mpps)
- controls the number of pending packets
- total low-level control of queues state

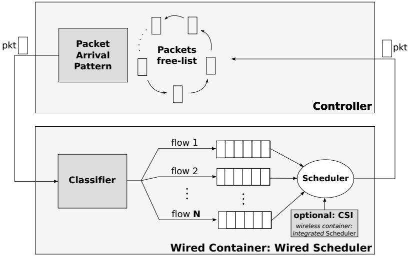


TEMPEST modules 2/3: The Container

TEMPEST Container

featherweight model which incapsulates a packet scheduler

- runs kernel code in user space
- easy code porting kernel ↔ tempest with trivial interface changes
- tracks information for QoS and throughput measurements

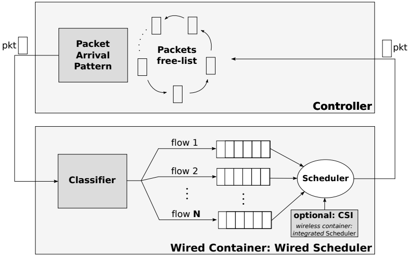


TEMPEST modules 3/3: Channel State Information (CSI)

TEMPEST CSI

the simulation engine behind the wireless scenario representation

- optional block
- used for wireless simulations
- gives channel feedback: SnR or P_{loss}
- cross-layering solution



TEMPEST details

Core

TEMPEST gives a fine-grained level of configuration parameters in a hybrid simulation/emulation tool

Keypoints

From the **emulation** side:

- time is real
- code is real too

From the **simulation** side:

- QoS metrics are simulated
- Throughput and CSI are simulated
- simulated measures are exact!

TEMPEST default schedulers

- **DRR**: $\mathcal{O}(1)$ time complexity, $\mathcal{O}(n)$ deviation from optimal service
- **WF^{2}Q+**: a *timestamp-based* algorithm with optimal service guarantees in $\mathcal{O}(logn)$ time
- **KPS**: approximated timestamp-based schedulers with near-optimal guarantees and $\mathcal{O}(1)$ time complexity (slower than DRR)
- **QFQ**: approximated timestamp-based schedulers with near-optimal guarantees and $\mathcal{O}(1)$ time complexity (as fast as DRR)
- **QFQ+**: improvement of QFQ sometimes faster than DRR
- **W^{2}F^{2}Q**: integrated packet scheduler for wireless link based on WF^{2}Q+ algorithm
- **HFS**: a modular packet scheduler for wireless link, based on QFQ+, with $\mathcal{O}(1)$ time complexity, quasi-optimal service guarantees, high throughput and low energy consumption

TEMPEST input parameters

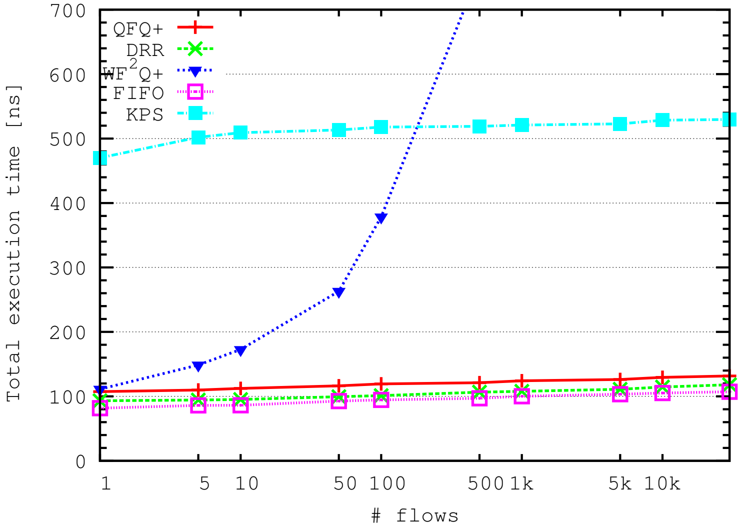
	parameter	short description	default value
	`n`	amount of events for the run	null
controller	`qmin`	min controller's pending packets	0
controller	`qmax`	max controller's pending packets	0
controller	`len`	length of packets in byte	1700
controller	`burst`	set predefined packet arrival patters	0
controller	`qsing`	minimum packets number per flow	0
container	`mode`	choose the container	null
container	`alg`	scheduler algorithm	FIFO
container	`qos`	QoS scheduler algorithm	null
container	`mac`	MAC scheduler algorithm	null
container	`flowsets`	define the QoS flows characteristics	null
container	`flows`	define the number of QoS flows	0
container	`flowsetsmac`	define the MAC flows characteristics	null
container	`flowsmac`	define the number of MAC flows	0
container	`qmac`	define the Q shared-buffer size in packets	0
CSI	`wdistr`	define MAC weight distribution	0
CSI	`ploss`	assign a packet loss for each MAC flow	null
	`intgr_th`	define the good/bad threshold	50%

Choosing the right scheduler

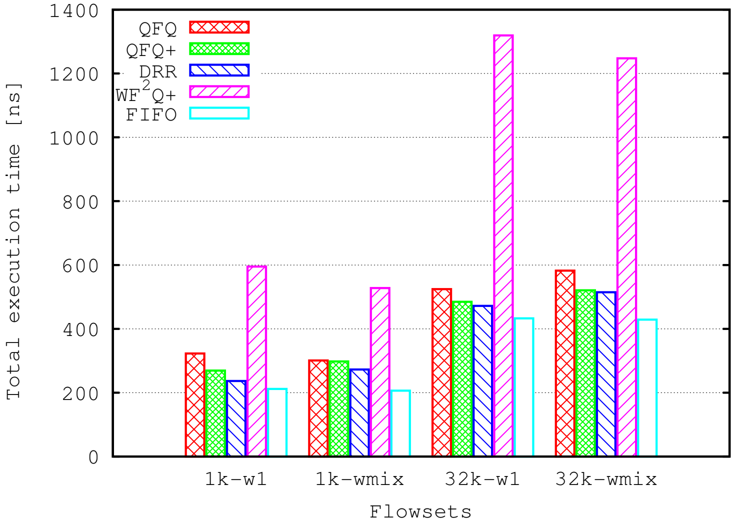
We have many algorithms with different features. How do we choose?

- it depends on the operating conditions:
  - for large N, asymptotic complexity is important.
  - for small N, or certain weight distributions, guarantees or *actual* run times are more important
- theory can tell us about worst-case service guarantees and asymptotic complexity
- we need measurements to determine the run-time constants

Execution time behavior for different schedulers (lower is better)



Execution time with *bursty* packets arrival pattern (lower is better)

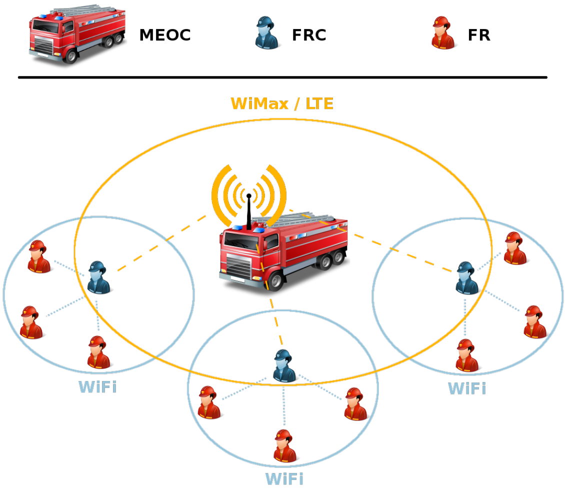


Implementing novel solutions in challenging scenarios

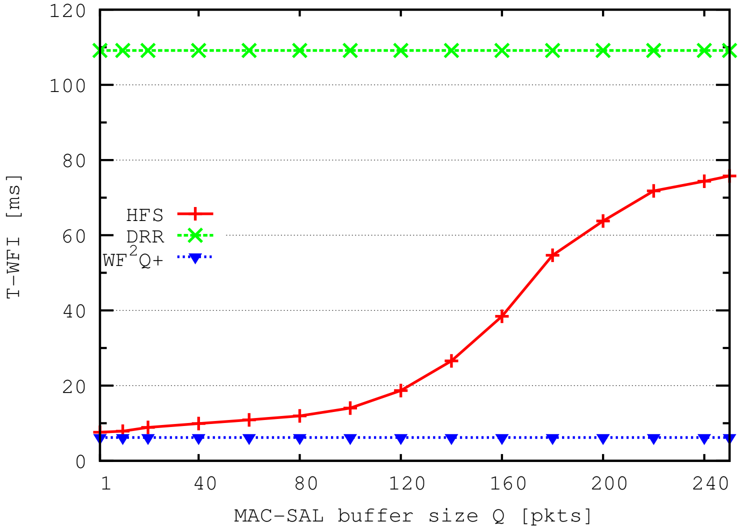
We have several novel technologies QoS driven:

- quickly evaluate novel scheduling solution
- real code is basically the TEMPEST code
- PPDR systems are a perfect challenging example:
  - technologies/architectures used are still evolving
  - thin QoS guarantees on a tough environment

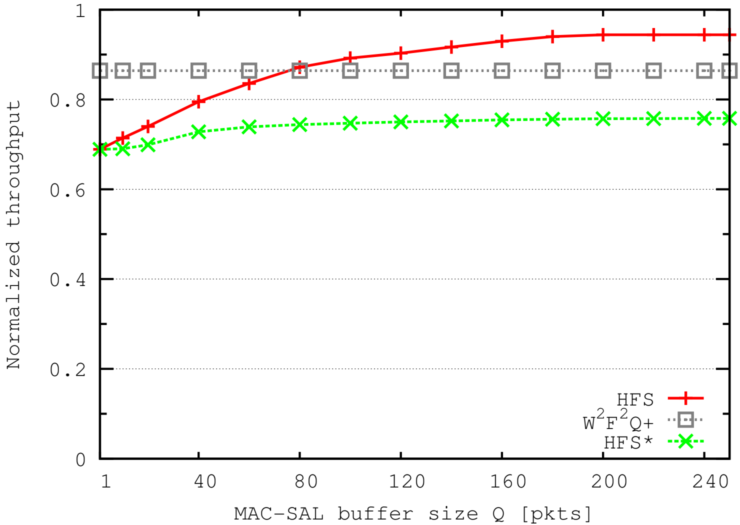
PPDR case study



PPDR case study: T-WFI for different scheduler (lower is better)



PPDR case study: throughput achieved (higher is better)



Conclusions

TEMPEST

a novel test environment for packet scheduling evaluation/implementation

Characteristics

- open and UNIX based
- hybrid simulator-emulator
- measures all the main figures of merit
- flexible and suitable for PPDR systems and challenging environments
- tests proof its accuracy
- support novel technologies/standards
- help research!

thank you
for your attention

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extra slides

Reference Scenario

- 20 first responders (FR)
- link rate 54 Mb/s
- one MAC-SAL flow per FR
- MAC-SAL flow packet loss probability
  - ranging linearly from 10^0 to 10^{-1}
  - outsider values as 10^{-2}, 10^{-3} and 10^{-4}
  - static
- MAC-SAL flow weight distribution
  - analogical: $\phi_k = (1 - \mathsf{P}_{loss_k}) \cdot 1000$
- 100 QoS flows with different weights