

# OAI eNB Real-Time on Limited-CPU Machine

# CPU burns electricity

All modern CPU are limited by thermal dissipation

- C-states
- Core state from C0 (active) to C7 (deep sleep)
- Maximum transition: less than 200 $\mu$ s

P-states = core frequency

- Harms because the frequency choice is based on sliding average

Thermal protection

- Intel Power clamp should not activate itself

Hyperthreading

- A commercial trick, not twice the cores

# Linux scheduling

## Preemption

- Low latency Linux
  - 1000 Hz scheduler: 1 milisecond
  - Is not what we need

## No preemption

- Most real-time OS doesn't use preemption
- Openair has a embeded scheduler: LTE frame

## How to

- Reserve cores for eNB critical part (frame processing)
- Keep at least one core for other tasks
- Be aware of shared HW: RAM with video processor, various resources with cards like WiFi

# USB dialog

## USB messages

- Big messages save CPU but increase latency
- UHD involves memory to memory transformations
  - Each memory copy costs

# OpenAir realtime issues

## No core isolation

- Linux can keep up to 1ms (low latency kernel) core before next preemption
- Shared hardware not monitored

## Useless recommendations

- Block C-state to C0 saves 2 $\mu$ s maximum latency (from C1)
- Hyper-threading harms only if Linux grabs the uniq core
- Low latency kernel is far too slow

## Over complex operations

- Each call to the kernel, to `pthread_mutex()` has a cost

# OpenAir realtime issues

## Total CPU is the limit

- Operations can be done with less CPU
- OpenAir already uses SIMD
  - The corner stone of last ten years CPU improvements
  - No LTE realtime SDR is possible without SIMD instructions
- Faster blocks can be made
  - Turbo codec
  - Modulation, scrambling
  - ...
  - PHY processing is the actual limit of SDR

# Open cells on going code

## Run on stock Linux

- Core isolation helps to make more stable execution

## Improvements done on « old develop » branch

- Simplified build, less files
- ITTI recoded, and many « utilities »: log, mem allocation, ...
- Much less threads
- CPU saves in several critical places
- Reworked sub frame numbering and processing to use the LTE 3ms jitter

# Open cells on going code

## Merge in near future

- Since new develop is available, we can merge
  - Some is already in
  - Some will be merged, nevertheless we did similar things
  - Some will remain separate
    - Not common like build, logs
    - Commercial offer from Open Cells company



# Demonstrated system

## I5-4300M CPU, single memory channel

- 2013 laptop CPU, comparable to i7-xxxxU recent series
- USRP B210
- Commercial UE
- All in one configuration: eNB + EPC
  - See: <https://open-cells.com/index.php/2017/08/22/all-in-one-openairinterface-august-22nd/>

## Show

- Full rate traffic 5MHz
- Runs 10MHz, nevertheless a bug prevent to traffic
- Runs 20MHz, but not enough CPU for payload processing