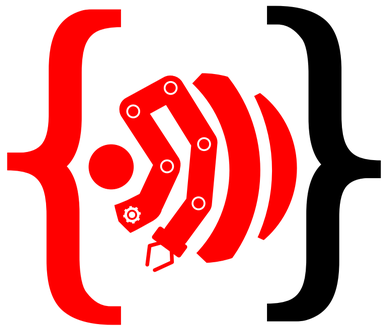

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Talking to Cellular Modems

with microcontrollers

David Čermák

Speaker Intro

ESPRESSIF DevCon23

- Embedded software developer
- ESP-IDF project contributor
- Networking and Protocols team manager at Espressif

David Čermák

Talking to Cellular Modems

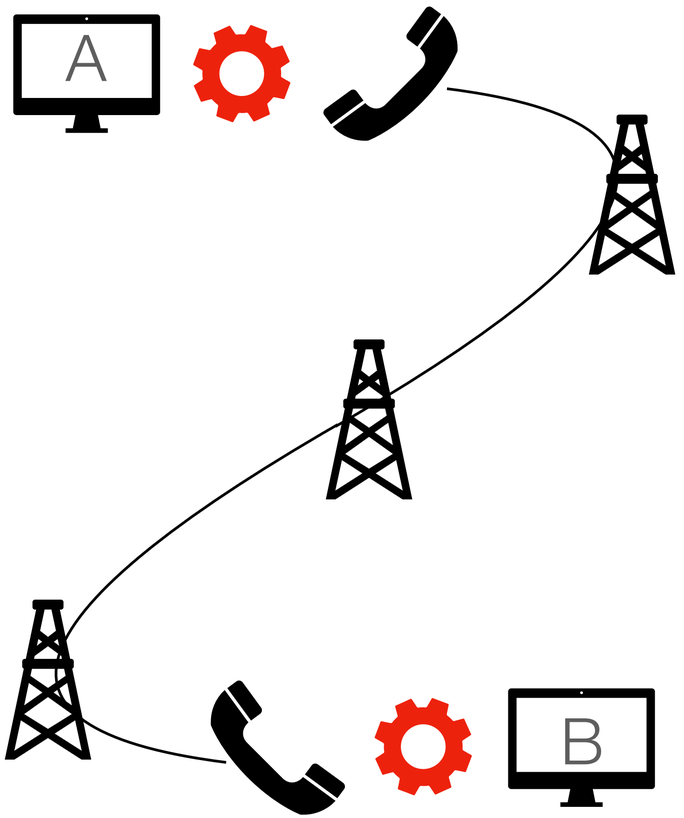
Analogue modem
with acoustic coupler
and a telephone

Source: Wikipedia

Talking to Cellular Modems

Modulate

Demodulate

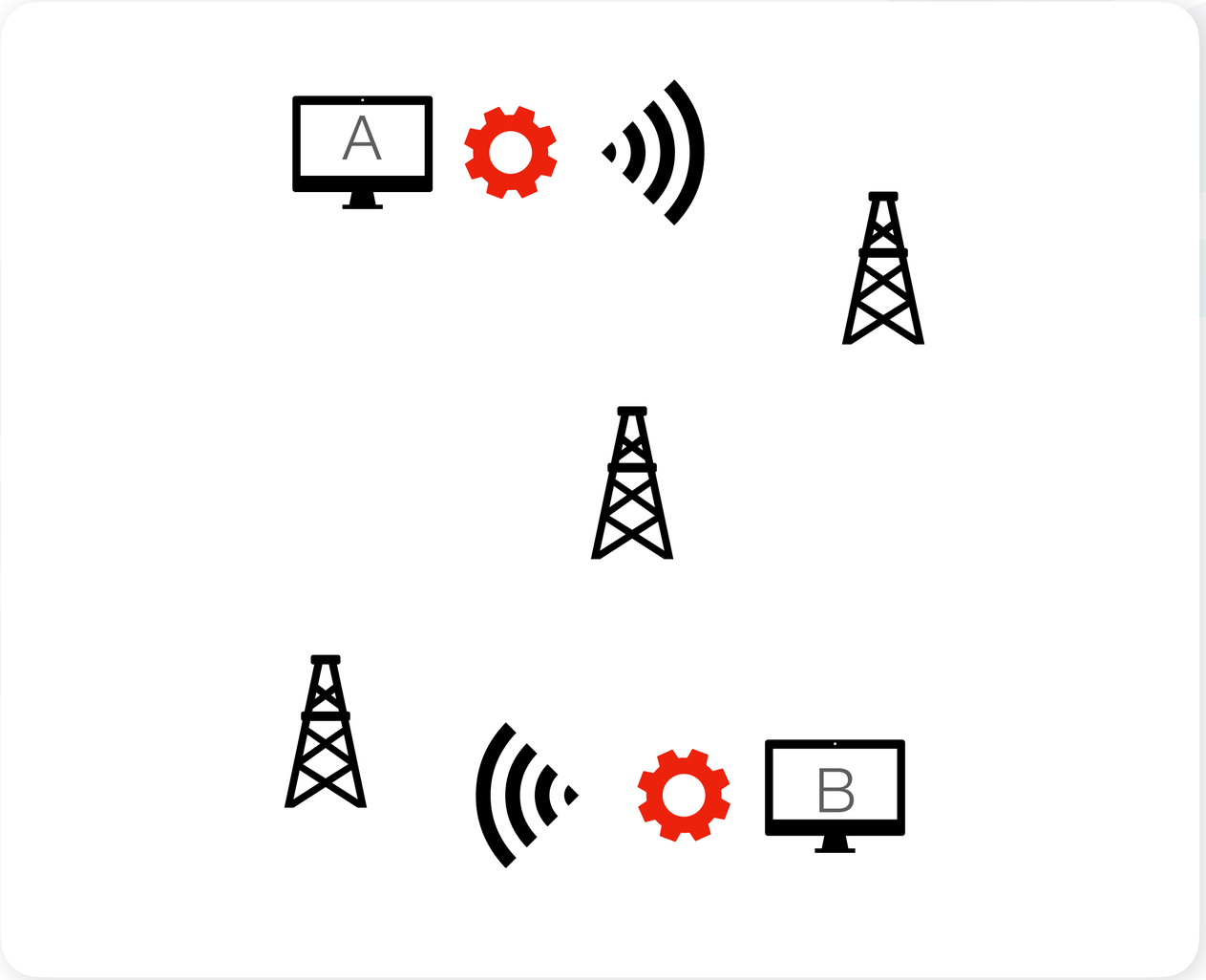


Talking to Cellular Modems

GSM, 2G, 3G

LTE

NB-IoT



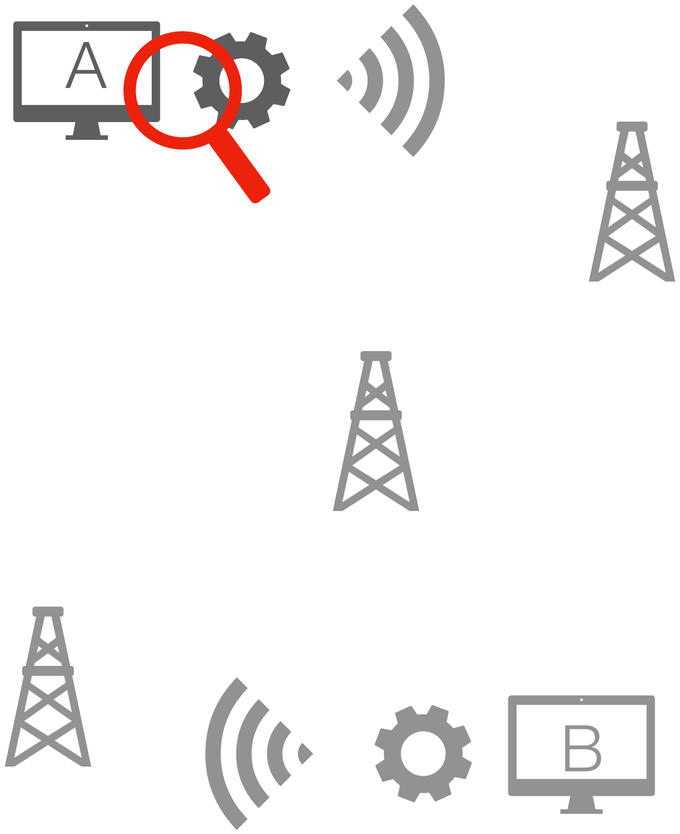
Talking to Cellular Modems

Interface between

- Microcontroller
- Modem

Over UART

With AT commands



CONTENTS

- Protocols, interfaces
- Commands, network
- Tips and Tricks
- OTA
- ESP-IDF solutions

01

Protocols, interfaces

V.25TER, PPP, MBIM,
GSM 07.10, USB, UART

Most popular modems

Features

Interfaces
UART
USB (for diagnostics)
DDC (I2C)
USIM
GPIO

Features
Secure cloud services
u-blox SARA-R5 Series LTE-M/NB-IoT
Antenna dynamic tuning
CellTime
Ultra low PSM
TCP/UDP
HTTP, FTP
TLS/DTLS
FW update via serial (FOAT)
uFOTA
LwM2M, dynamically loaded objects
MQTT, MQTT-SN
CoAP

Most popular modems

Features

Size	26,5x22,5mm
Height	2,3 mm
Package	LGA
Interface	3xUART
Protocol	PPP, TCP, UDP
Other Features	

Interfaces
UART
USB (for diagnostics)
DDC (I2C)
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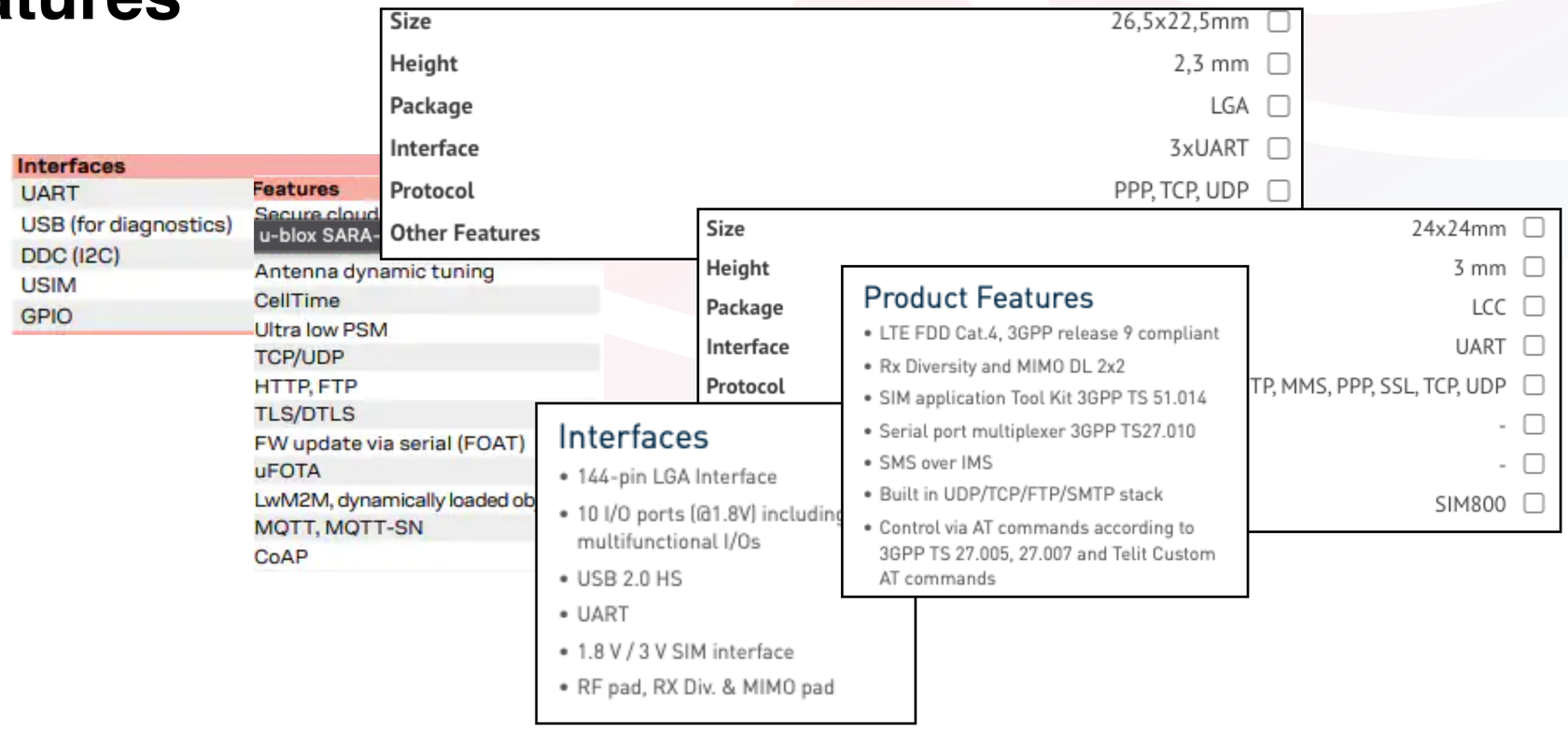
MQTT, MQTT-SN
CoAP

Size	24x24mm
Height	3 mm
Package	LCC
Interface	UART
Protocol	FTP, HTTP, MMS, PPP, SSL, TCP, UDP
Other Features	-
GNSS	-
Série	SIM800

Most popular modems

Features



Interfaces
UART
USB (for diagnostics)
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Protocol	TP, MMS, PPP, SSL, TCP, UDP
	-
	-
	SIM800

Interfaces

- 144-pin LGA Interface
- 10 I/O ports (@1.8V) including multifunctional I/Os
- USB 2.0 HS
- UART
- 1.8 V / 3 V SIM interface
- RF pad, RX Div. & MIMO pad

Product Features

- LTE FDD Cat.4, 3GPP release 9 compliant
- Rx Diversity and MIMO DL 2x2
- SIM application Tool Kit 3GPP TS 51.014
- Serial port multiplexer 3GPP TS27.010
- SMS over IMS
- Built in UDP/TCP/FTP/SMTP stack
- Control via AT commands according to 3GPP TS 27.005, 27.007 and Telit Custom AT commands

Talking to modems

Interfaces

- UART
- USB
- I2C, SPI
- ePCI

Protocols

- AT commands (V.25TER and others)
- PPP, TCP, UDP, MQTT, HTTPS, …
- CMUX (GSM 07.10)
- MBIM

Talking to modems

Interfaces

- UART
- USB
- I2C, SPI
- ePCI

Protocols

- AT commands (V.25TER and others)
- PPP, TCP, UDP, MQTT, HTTPS, …
- CMUX (GSM 07.10)
- MBIM

02

Commands, network

AT+CPIP

PPP: LCP, IPCP, IPv6CP

Talking to modems

Commands

- Request/Response
- Get/Set properties
- Send text message
- Get NMEA

Network

- Maintain active connection

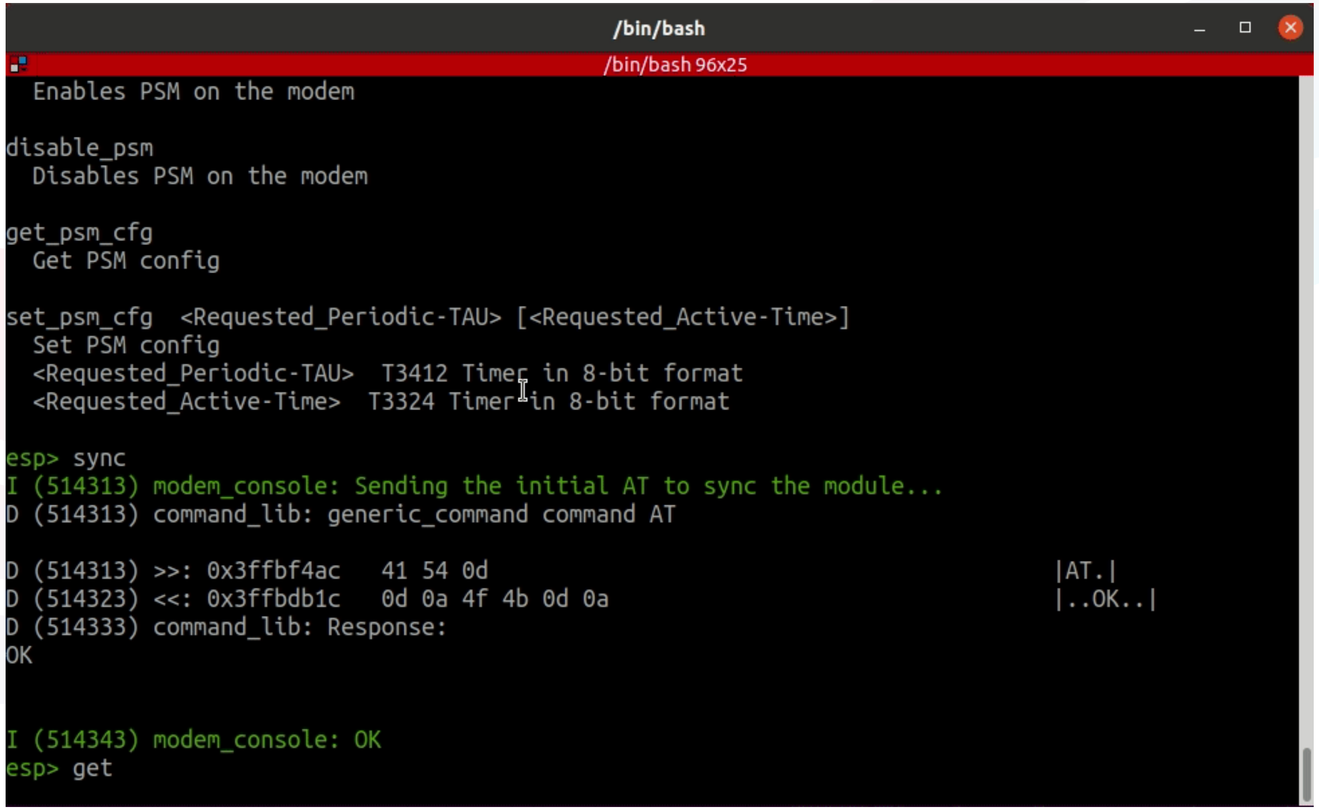
Talking to modems

Commands

- Request/Response
- Get/Set properties
- Send text message
- Get NMEA

Network

- Maintain active connection



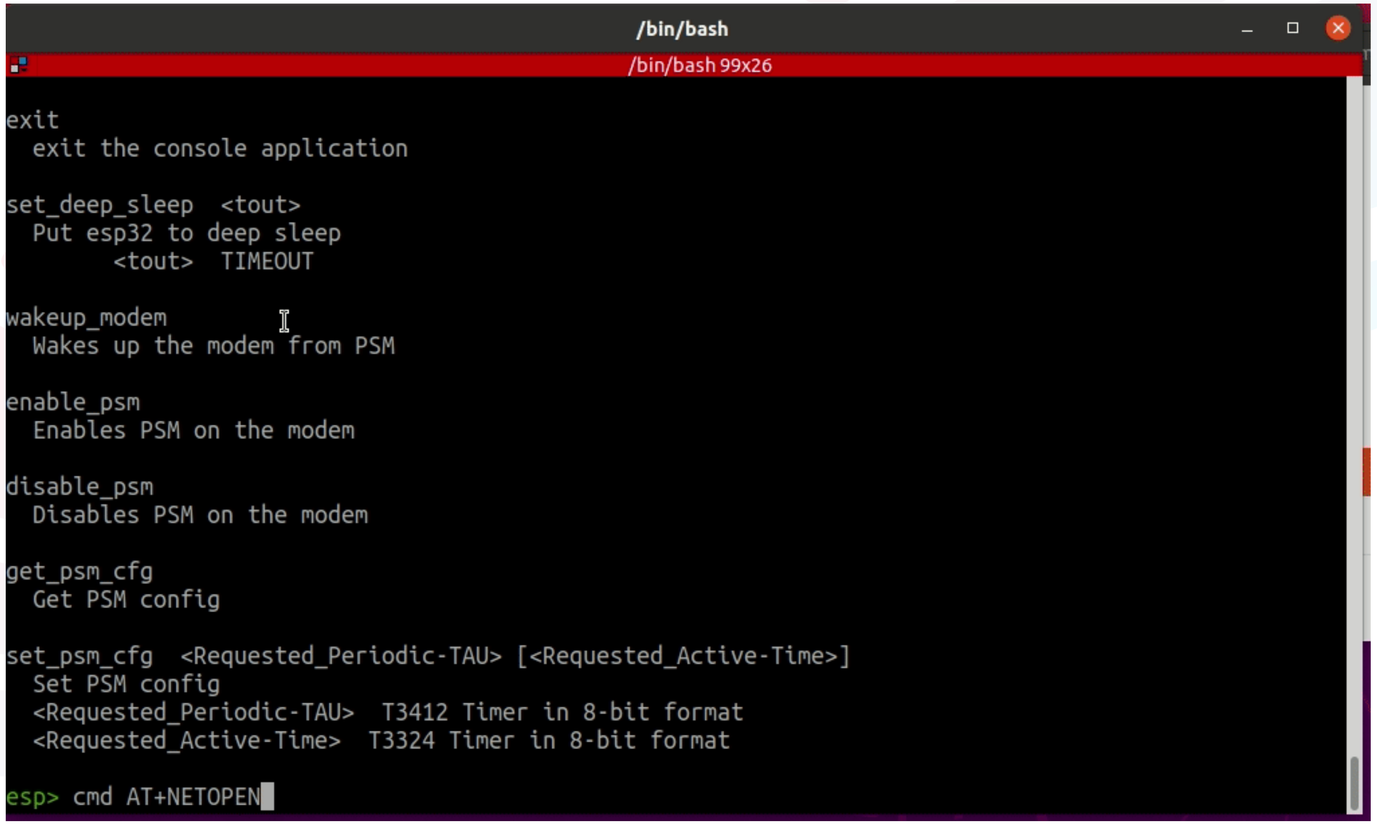
Talking to modems

Commands

- Request/Response
- Get/Set properties
- Send text message
- Get NMEA

Network

- AT commands
- PPP: Collection of Point to Point Protocols



Talking to modems

Commands

- Request/Response
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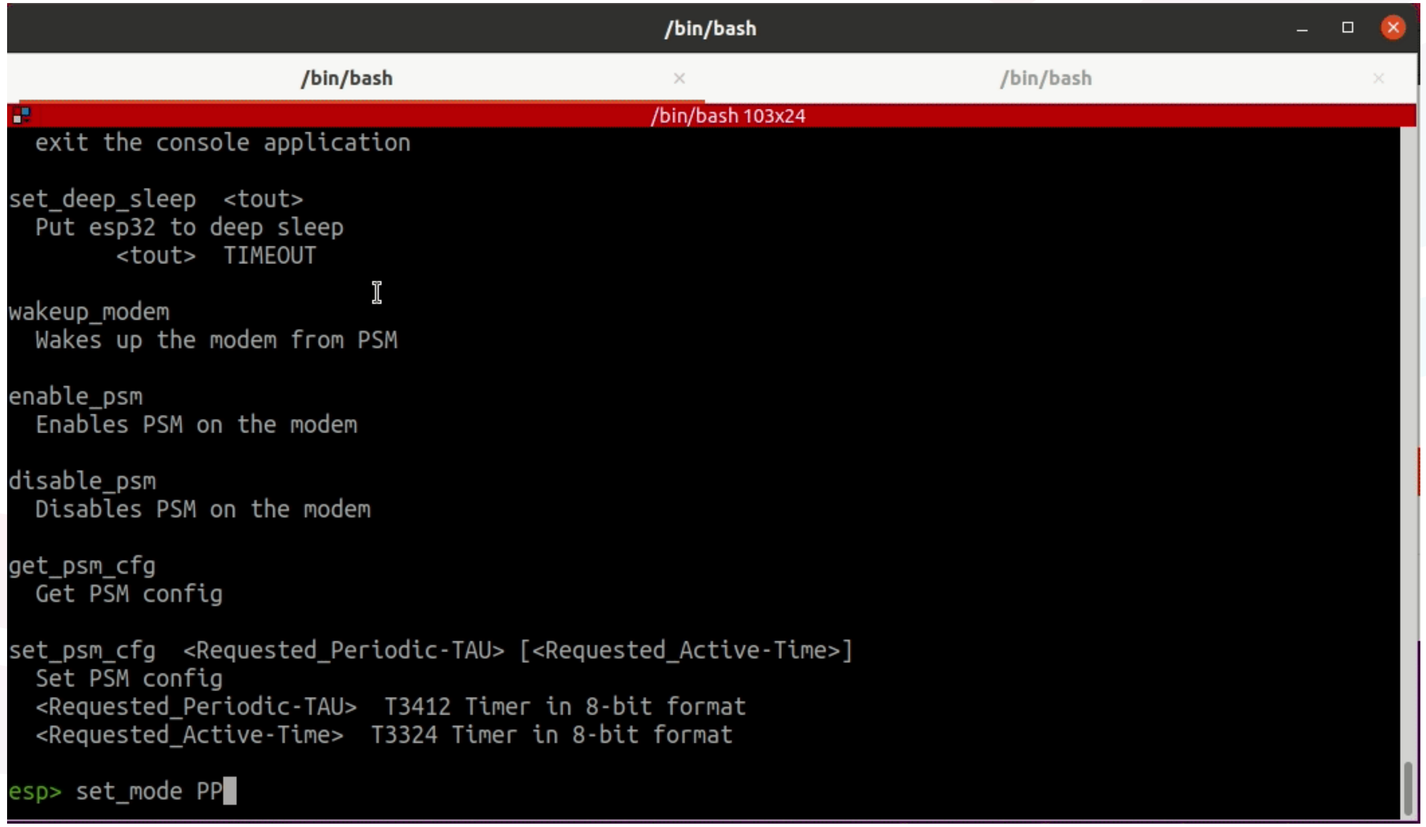
Network

- AT commands
- PPP: Collection of Point to Point Protocols



03

Tips & Tricks

Simultaneous network and command interface

Commands and Network

One channel for both network data and command interface (request-response)

01

Switching between PPP and AT mode

02

CMUX: Using channel multiplexer

03

Serve network using AT commands

04

Use two physical channels (in one USB)

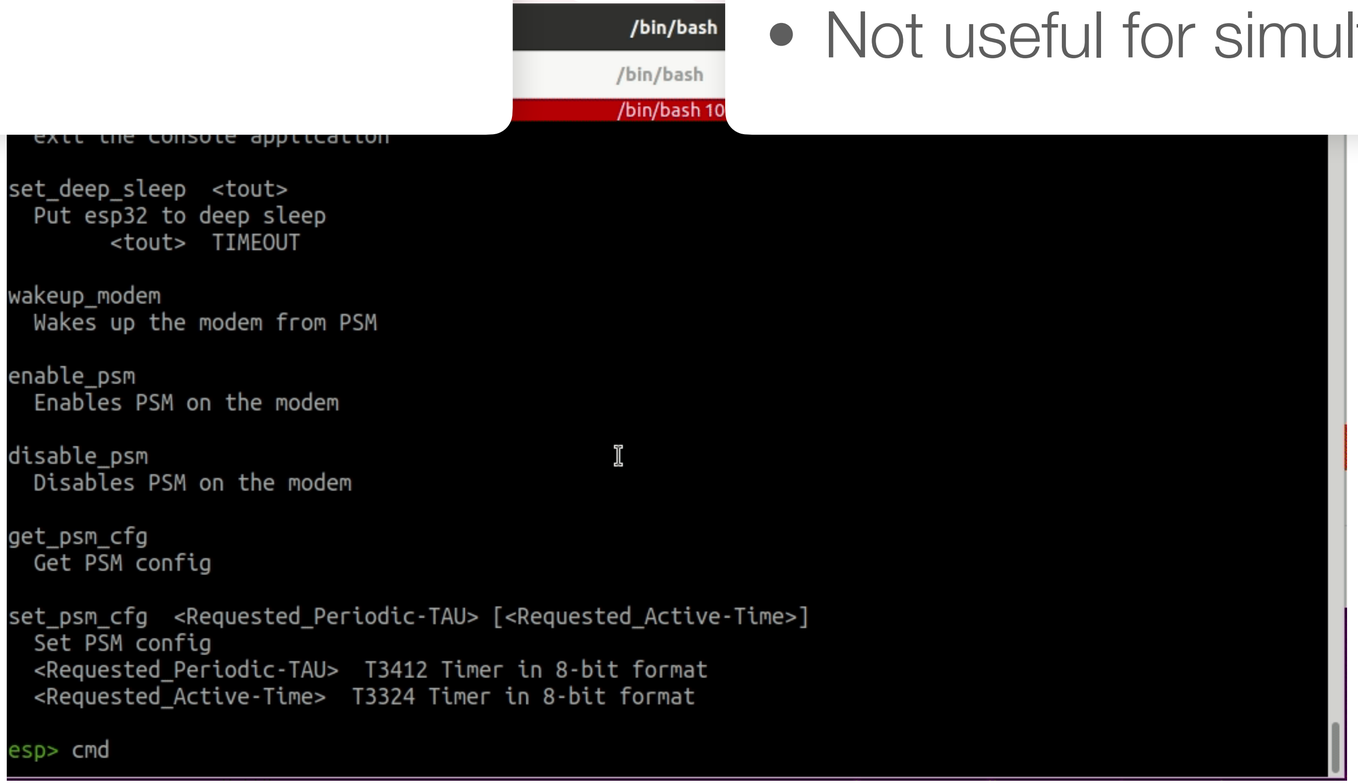
Switching between modes

Pluses

- No need for a library
- Supported by most modems
- Most reliable

Minuses

- Switching sequence might differ
- Slow
- Not useful for simultaneous requests



Switching between modes

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Pluses

- No need for a library
- Supported by most modems
- Most reliable

Minuses

- Switching sequence might differ
- Slow
- Not useful for simultaneous requests

Network applications that need send commands.
Sleepy applications that wake up, establish connection and go to sleep again.

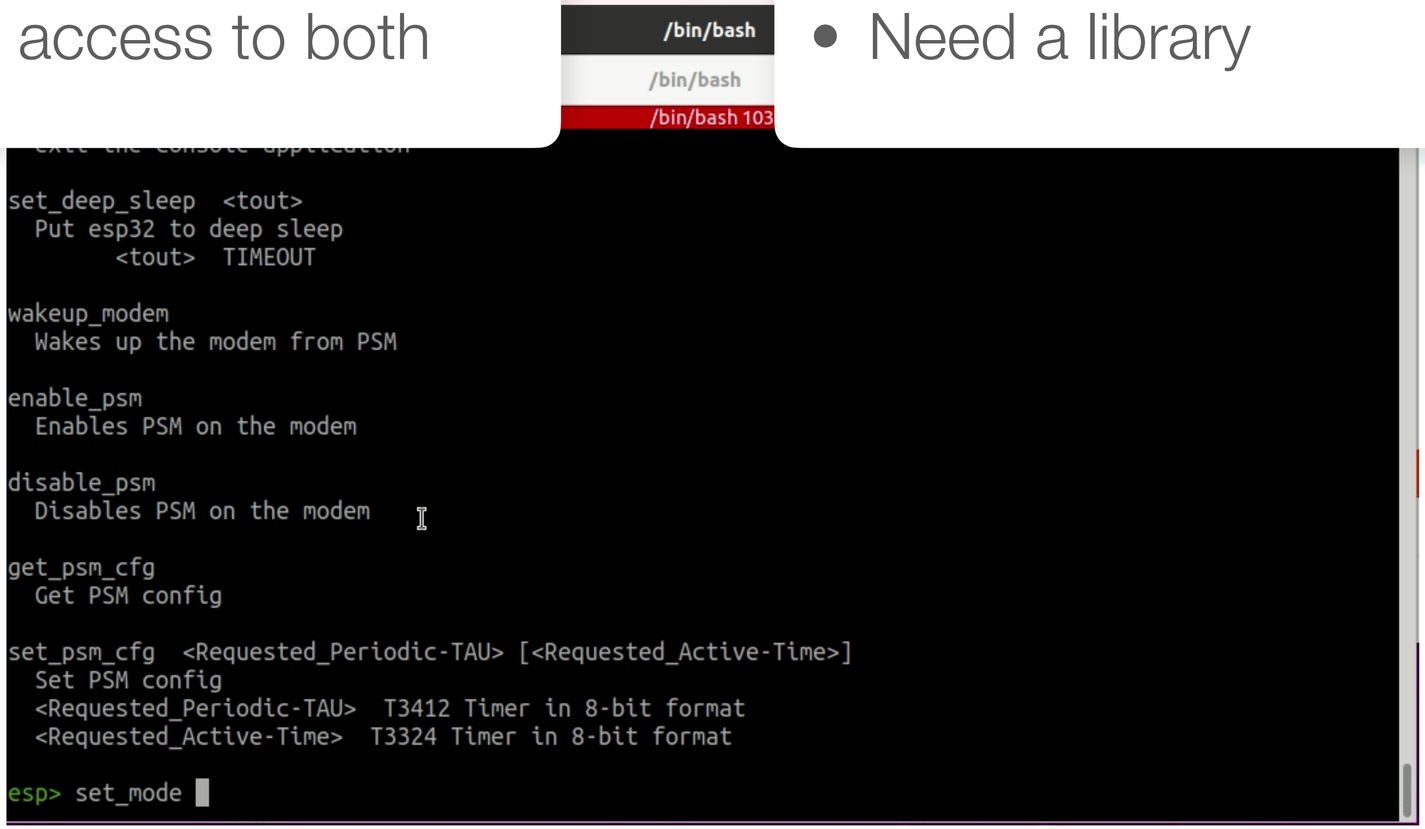
CMUX mode

Pluses

- The most traditional approach
- Simultaneous access to both

Minuses

- Protocol might differ per device
- Need a library



CMUX mode

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Pluses

- The most traditional approach
- Simultaneous access to both
- No switching modes

Minuses

- Protocol might differ per device
- Need a library

Applications that need both commands and network.
Choose the device that supports CMUX.

Networking with AT

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Pluses

- No switching modes
- Available in most devices

Minuses

- Network commands are different
- Security?
- Protocol libraries?

Applications that need commands with occasional networking.

Two physical channels

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Pluses

- Best choice if the device supports it

Minuses

- Portability

Devices with USB interface and two channels.

04

Tips & Tricks

Connectivity, OTA

Low power modes

Connectivity & OTA

Flow control

- Use if possible
- Not all devices support it

LCP echo

- Use if possible
- Link protocol to check connectivity

Connectivity & OTA

Two phase OTA

- Check image and pause network
- Bulk erase
- Resume network and OTA

Adjust library lower layers

- Handlers in IRAM
- Buffers
- Baudrate

05

Espressif solutions

ESP-IDF, lwIP

esp_modem

Using IDF only

Using only lwIP PPP

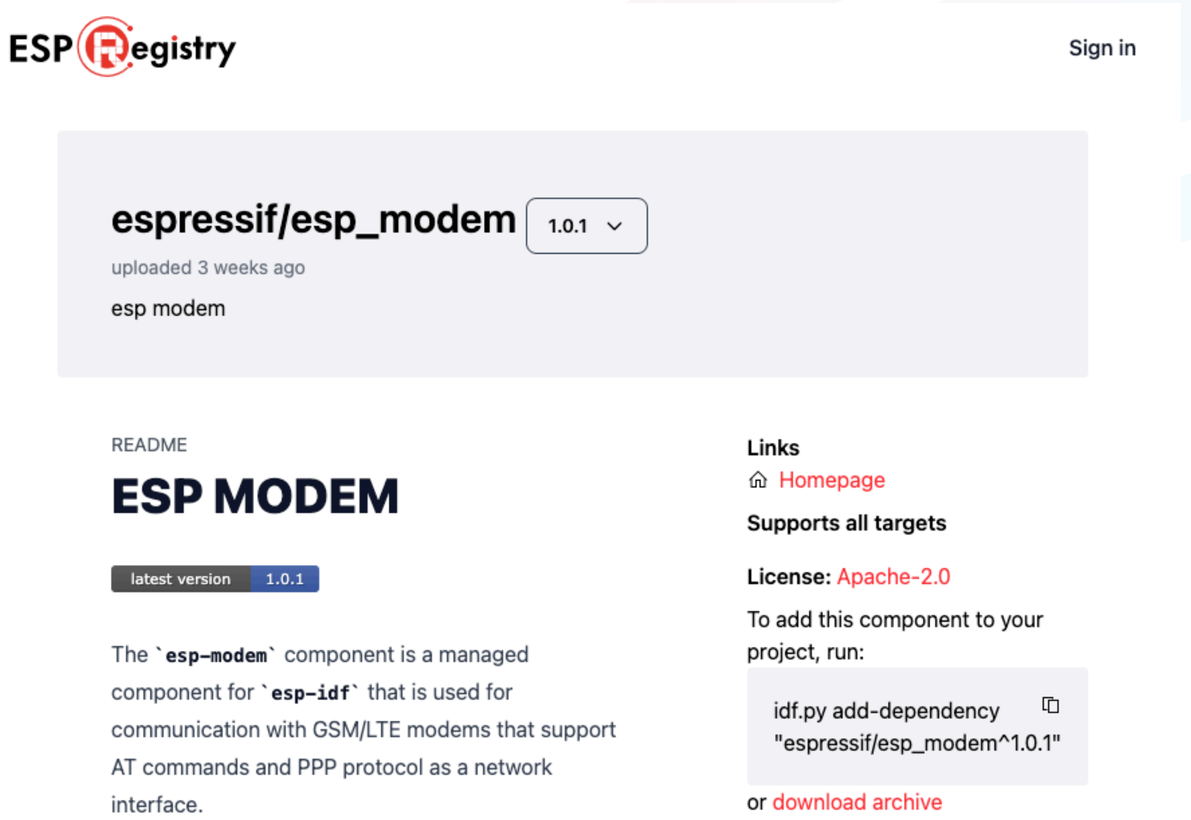
- Simple example
- ~100 lines of code
- esp-protocols/examples/esp_netif/multiple_netifs/main/ppp_connect_simple.c

(From multiple netif example, which uses Ethernet, WiFi and LTE: link)

Using esp-modem

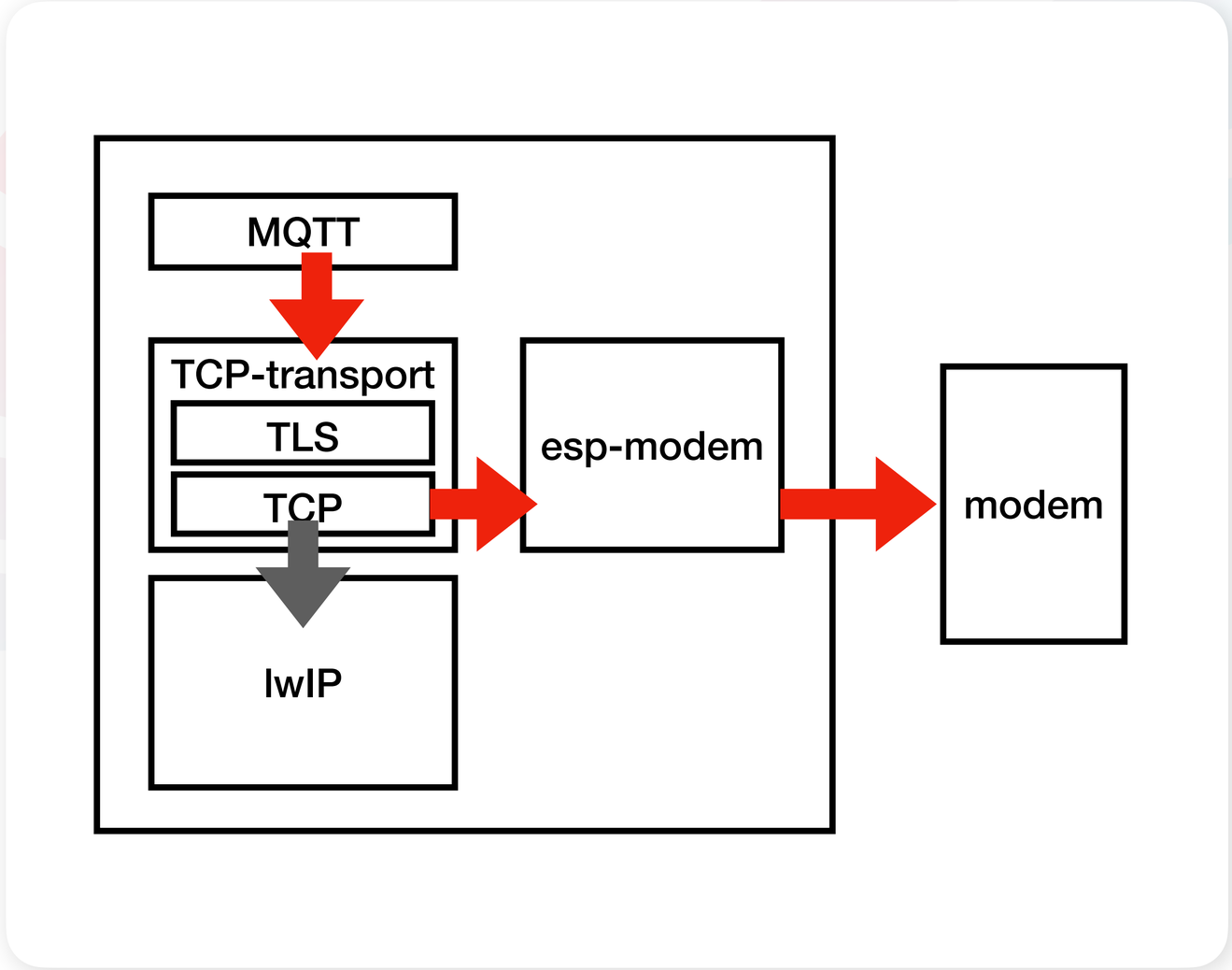
Features, examples

- CMUX support: link
- Power save mode example: link
- Known issues: link
- TCP client with AT commands: link
- Linux port: link
- Modem console: link



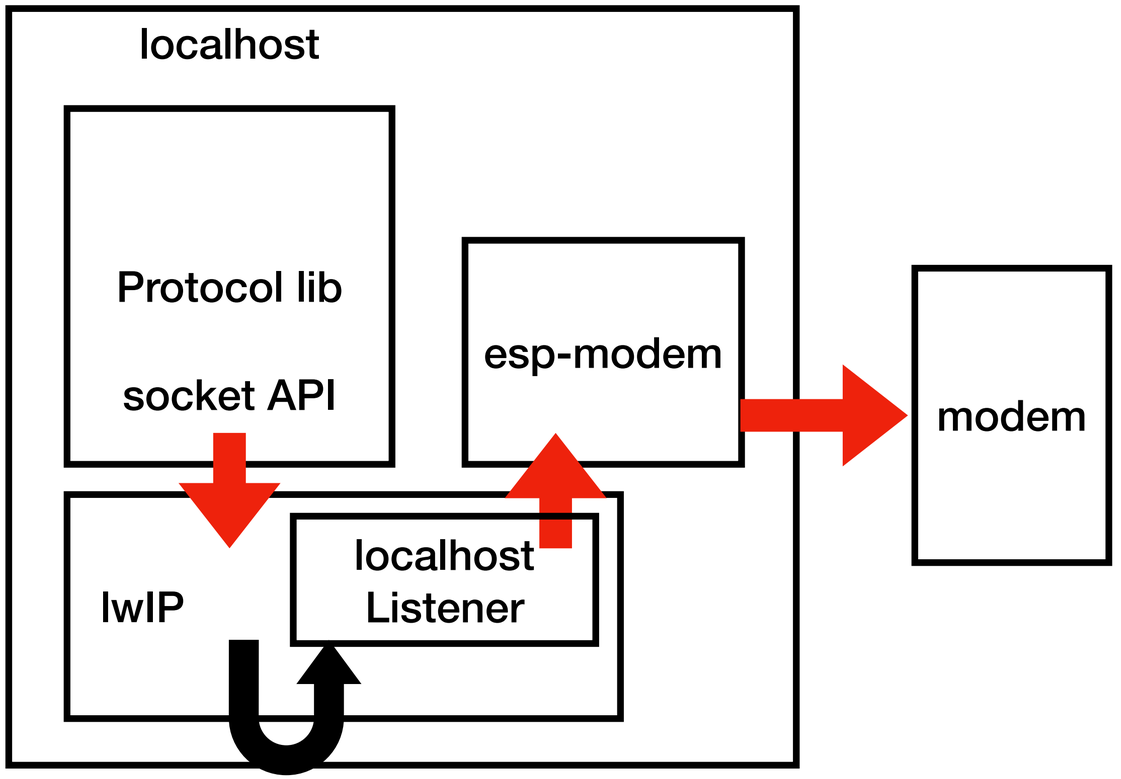
TCP client with AT

- IDF library with TCP transport
- `EXAMPLE_CUSTOM_TCP_TRANSPORT=y`



TCP client with AT

- Any library using
  - Socket API
  - lwIP raw API



Summary

Need commands and network?

- Use CMUX

Seen buffer overflow?

- Use flow control

Want to check something?

- Experiment with it in modem-console

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Thanks for watching !