An Internet perspective of 3GPP architecture

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Intent

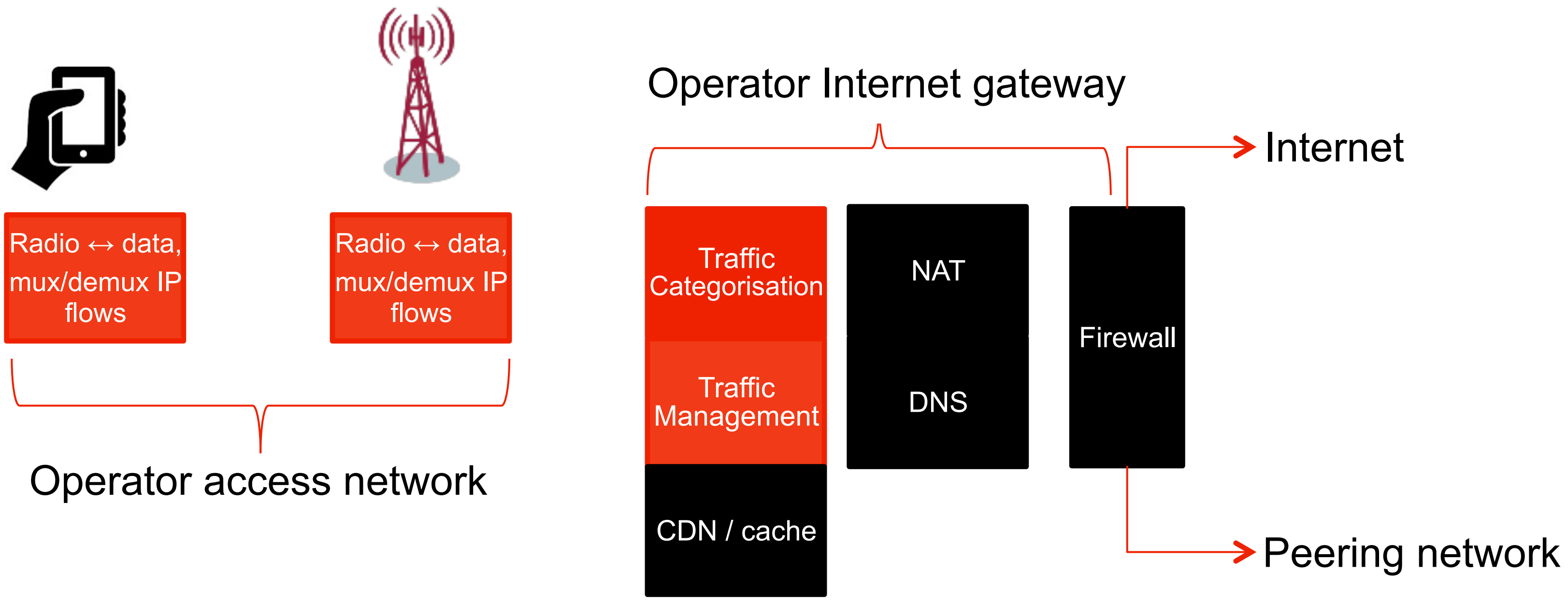
Show how a mobile network architecture manipulates and delivers Internet traffic

Keep it functional and not specific to a network standard

Assume all access signalling has been done, and the phone account is in credit….

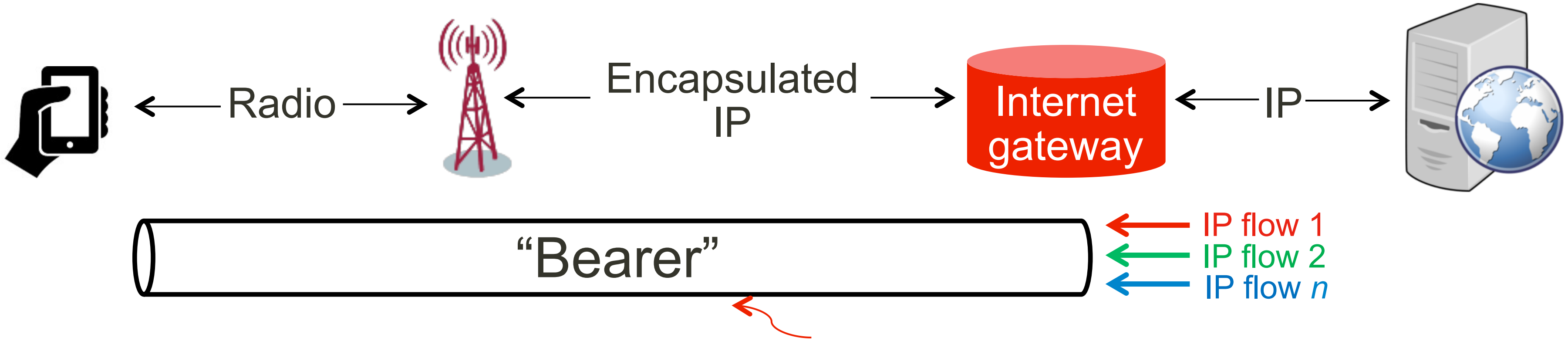
…but most of all, no telecoms acronyms. Or at least not many.

Mobile network functions that process Internet traffic



(Black boxes are not defined by 3GPP)

Notable concept #1: bearers



A bearer encapsulates a user's IP flows. A 'default bearer' is set up for every handset.

All flows on that default bearer are treated fairly (best effort) at the radio scheduler

Operators <u>may</u> set up dedicated bearers for certain Web traffic –
<u>but in practice this is not done</u>.

Notable concept #2: Volatility and mobility

Signal radio status

Radio signal to noise ratio varies rapidly and significantly.

Add changing load at the radio mast, or handover to a busier cell, and the result is volatile throughput .

Allocate radio resources

Schedule radio transmissions

Route to best cell

Volatility and mobility contribute to delay and jitter, meaning…

Notable concept #3: ‘Layer 2.5’ at the radio interface

These ‘layers’ help maintain IP connectivity, handle mobility and provide two styles of retransmission

<u>LOW LOSS</u>, due to two retransmission types:

- RELIABLE → RLC
- FAST → MAC

IP	
PDCP	Handover, header compression and crypto
RRC	Connectivity checks, resource allocation
RLC	Order packets, correct errors of MAC layer
MAC	
PHY	

Scheduling happens here

These retransmissions may affect…

Acronym apology corner:

Packet Data Convergence Protocol

Radio Resource Control

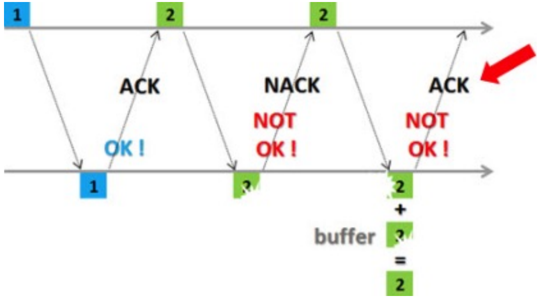
Radio Link Control

Behaviour of TCP in the mobile network

1 Noise and retransmissions here reduce throughput, which…

2 …can be interpreted as congestion by TCP endpoints

3 Meanwhile radio retransmissions are not in synch with TCP



4 So network may proxy TCP to attempt to fix this

= network and endpoints not working together on flow control

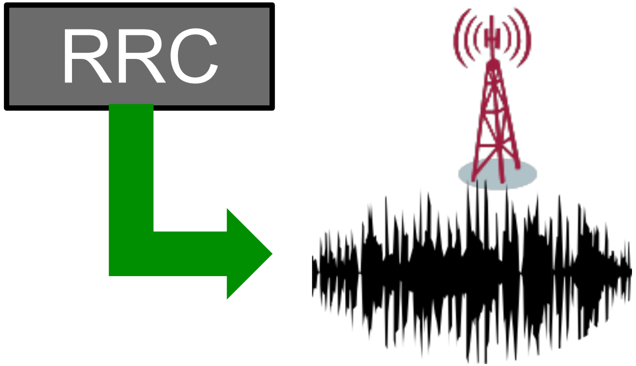
To bufferbloat, or not to bufferbloat?

Big buffers good!

- **Radio efficiency:** make use of resources as they become available
- Accounts for **volatility in bandwidth** (mobility/fading)
- Good for **bursts**

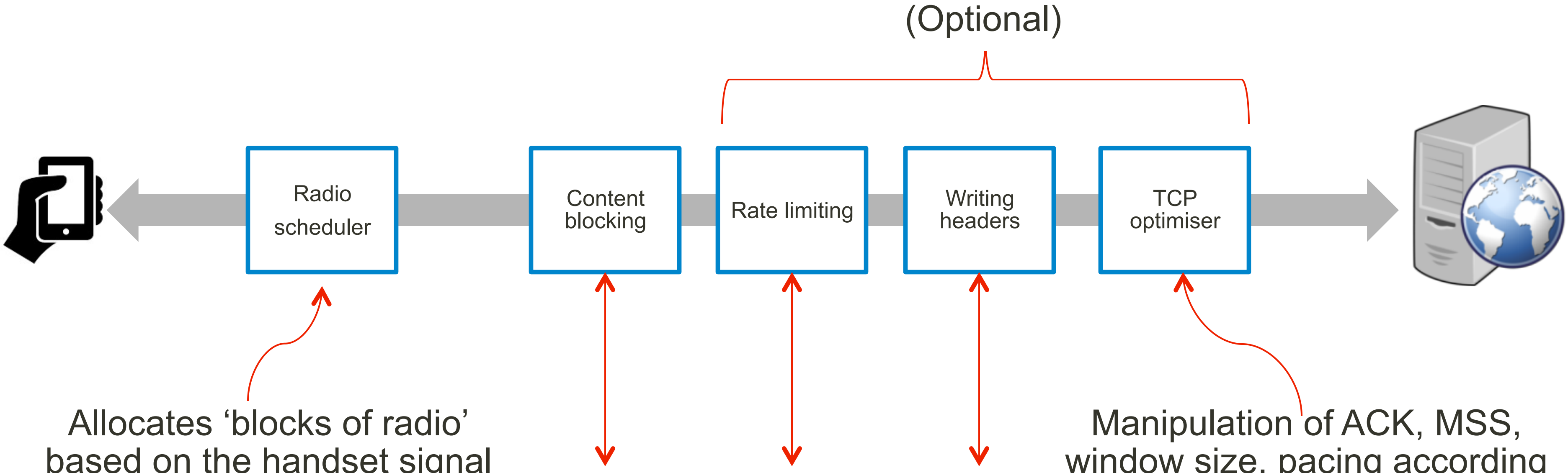
Big buffers bad!

- **Impacts TCP congestion control and flow control**– adds to jitter and latency
- Reduces **throughput**
- More chance of **packet loss at handover**



Key challenge: optimising buffer size at radio access layer

Traffic categorisation & management



Allocates 'blocks of radio' based on the handset signal health.

Buffer per user.

In practice this does not prioritise one Internet IP flow over another.

"Does policy apply to customer?" (this lookup can add latency)

Manipulation of ACK, MSS, window size, pacing according to available bandwidth at radio layer etc.

So: further Internet and mobile co-operation makes sense

Evolving TCP to account for mobile network conditions (TCP Prague, ConEx/ECN)

Co-operation between layer 2.5 retransmission and TCP RTO.

Transport hints between network and endpoints (evolution of SPUD, mobile throughput guidance, drop vs. queue)

Flow-agnostic queue management (DualQ, L4S)

Reassessing middleboxes (video optimisation in network vs. ABR, NAT vs IPv6 migration etc.) and dedicated bearers

Helping content providers debug customer issues

...and others!

"Improving customer experience without breaching customer privacy"