Tournament games for WiFi

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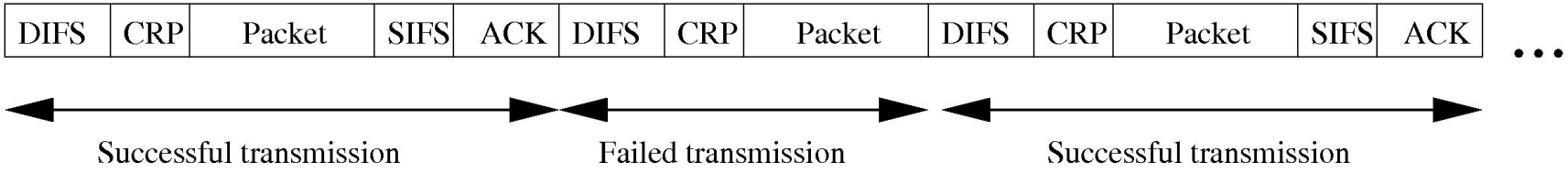
Why do we need to work on WiFi?

Different directions of work

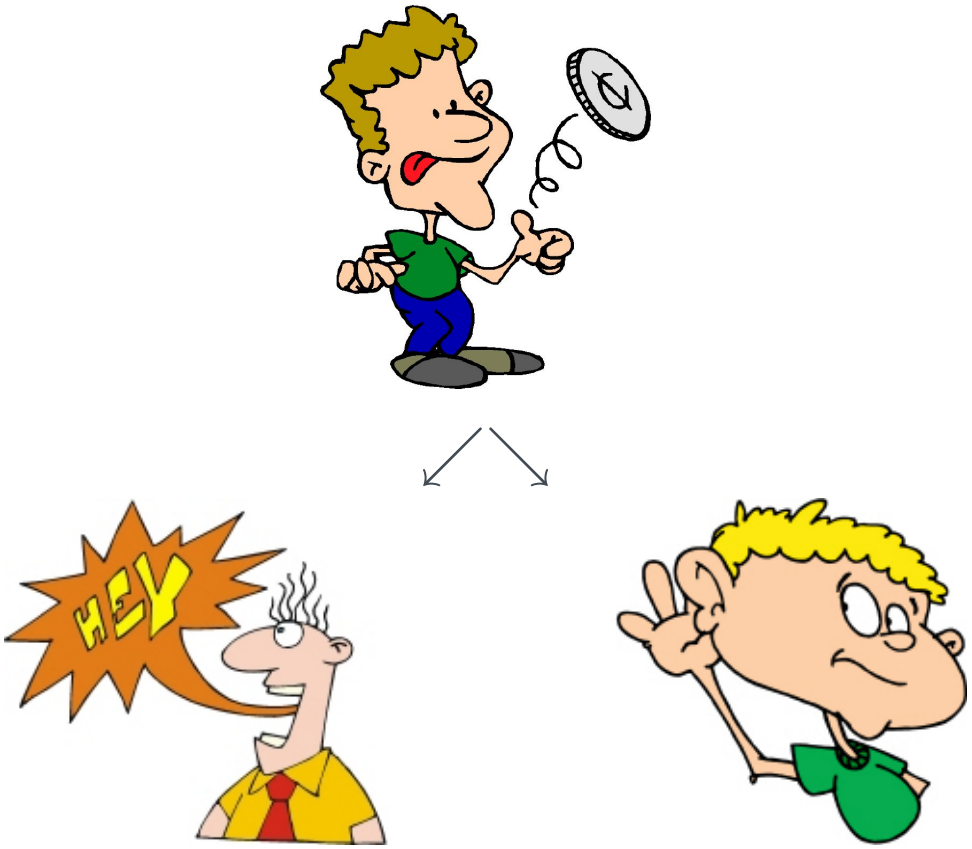
- Internet in the villages, with J.-C. Bermond, R. Klasing, S. Perennes, N. Morales : a 4-approximation for packet routing and hardness results.
- Spectral efficiency : Improving the capacity.
- QoS, with P. Brown : A protocol for Quality of Service.

Today a tournament formulation, with 802.11 DCF compatibility issues



What is our framework?

Principle



Practical example

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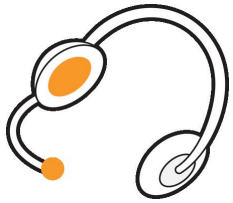

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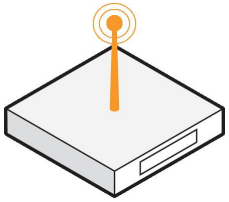

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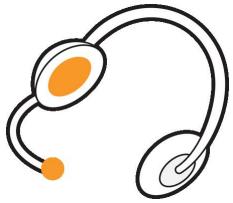

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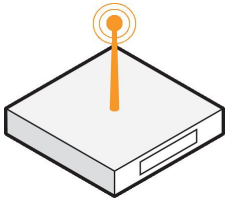

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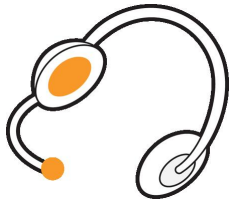

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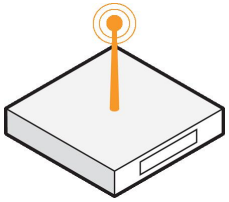

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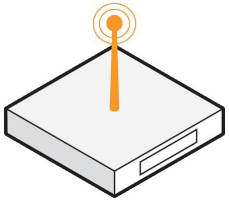

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How many players???

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$\longrightarrow$ no way (and no use) to set that in advance

The rules of the game

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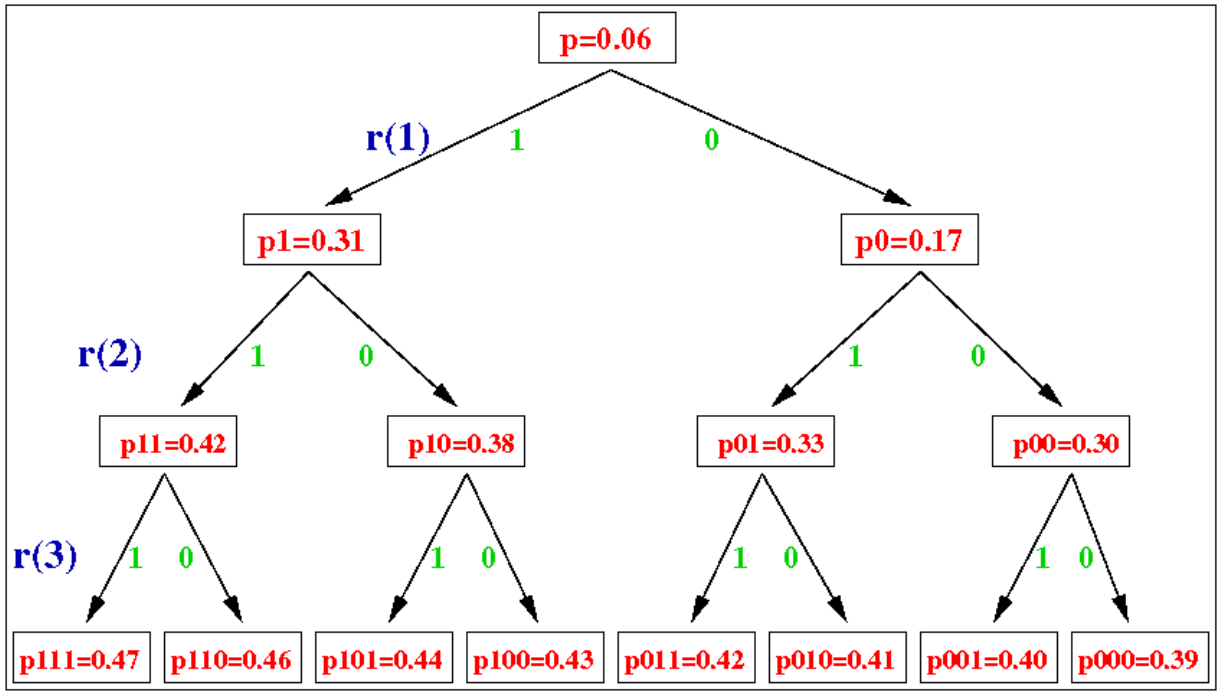
We need to find a strategy of tossing a biaised coin such that with maximum probability only one player survives at the end of the tournament.

Choosing the values



Mathematical analysis

A previous framework (with different hypotheses) has been done by Capetanakis, and later Fayolle, Flageolet and Jacquet based on tree protocols.

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We denote by q_n the probability that n stations try to emit in the system.

We define the generating function

$$f(x) = \sum_{n \geq 1} q_n x^n.$$

Getting further - emitting side

The distribution of the number of stations that emit is characterized by a generating function f_1, defined by:

$$f_1(x) = \sum_{i \geq 1} P[i \text{ stations emit a signal}] x^i.$$

$$\begin{aligned} f_1(x) &= \sum_{n \geq 1} \sum_{1 \leq i \leq n} \binom{n}{i} q_n p^i (1-p)^{n-i} x^i \\ &= \sum_{n \geq 1} q_n [(px + 1 - p)^n - (1-p)^n] \ . \\ &= f(px + 1 - p) - f(1-p) \end{aligned}$$

And we have:

Getting further - non emitting side

Similarly, in the event where no signal has been emitted at the first round, we write:

$$f_0(x) = \sum_{i \geq 0} P[i \text{ stations are present and remain silent}]x^i$$

then we obtain:

$$f_0(x) = \sum_{i \geq 0} q_i x^i (1-p)^i = f((1-p)x).$$

Getting further and further

w : a word in the alphabet $\{0, 1\}$,

$w0$: the same word to which the letter "0" is added,

$w1$: the same word to which the letter "1" is added,

p_w : probability corresponding to step w,

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$$\begin{cases} f_{w1}(x) = f_w(p_w x + 1 - p_w) - f_w(1 - p_w) \\ f_{w0}(x) = f_w((1 - p_w)x) \end{cases}$$

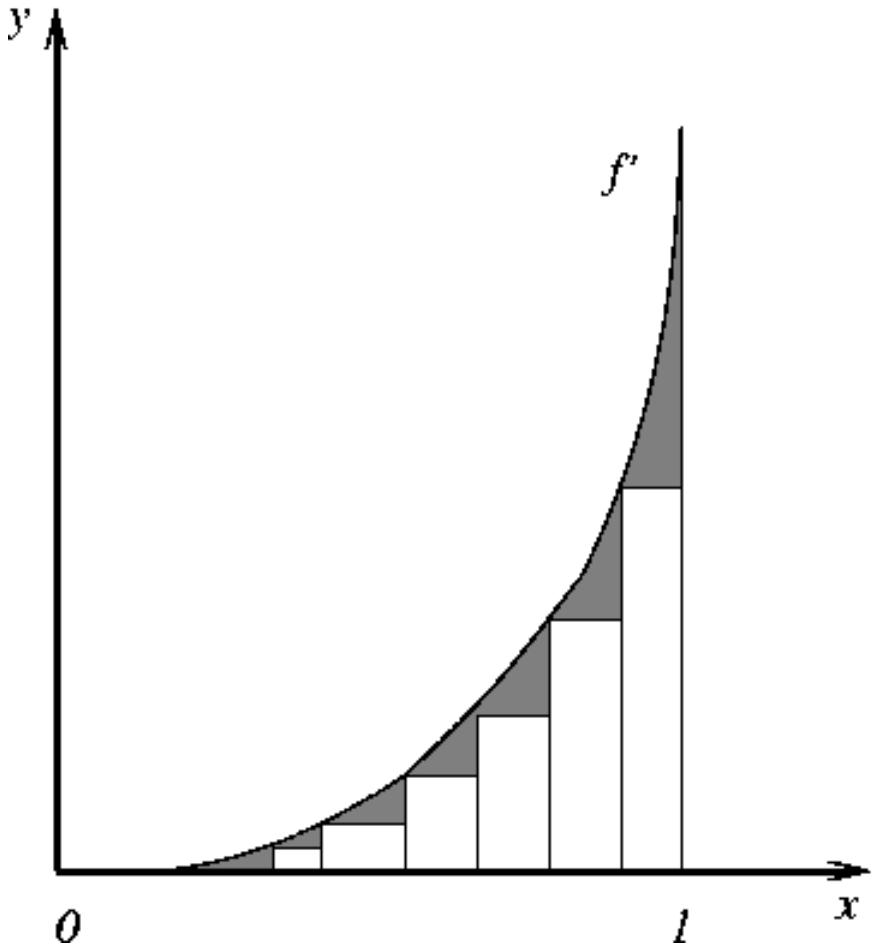
So what?

The probability of success ρ of the rounds of selection is the probability that only one station remains.

$$\rho = \sum_{w:l(w)=k} f'_w(0),$$

where $l(w)$ is the length of w.

Interpretation

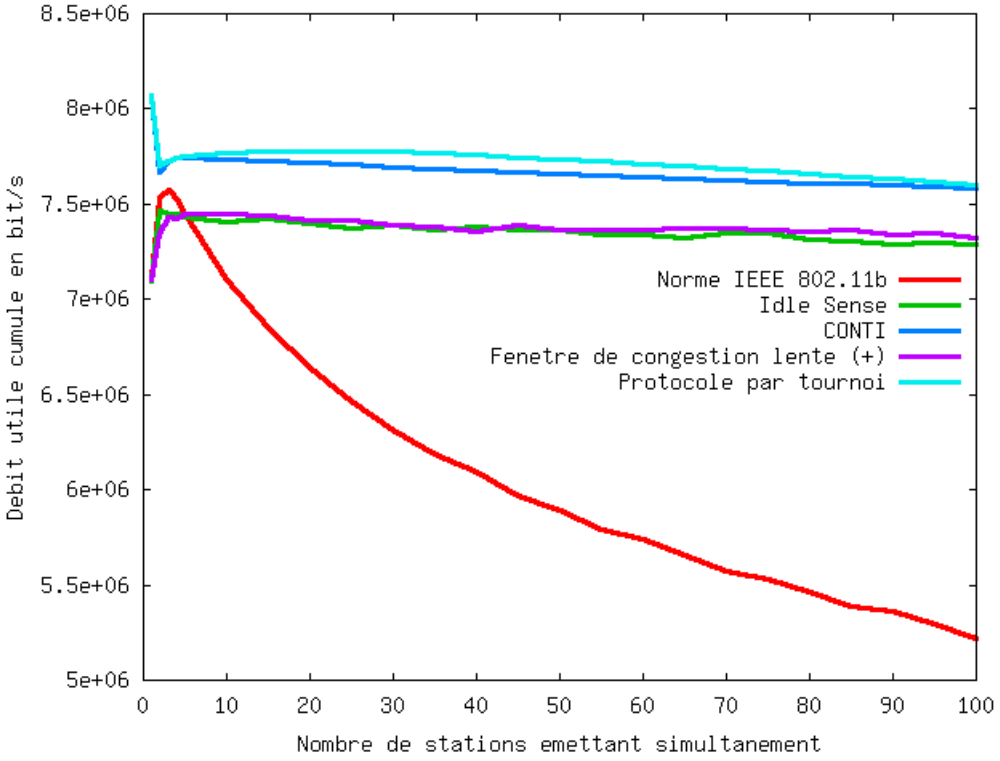


Assymptotical result

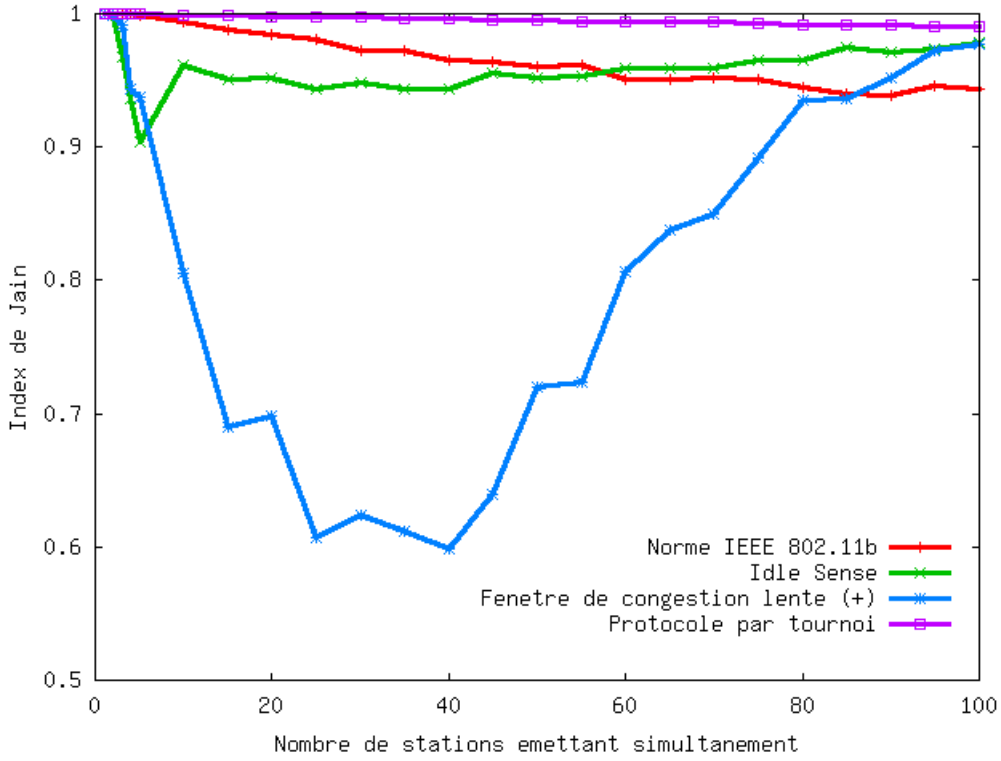
The maximum we can asymptotically expect for the collision rate is:

$$1 - \rho \approx \frac{\left(\int_0^1 \sqrt{f''(t)}dt\right)^2}{2^{\#rounds+1}}.$$

Practical results (simulations)



Compared throughput



Jain index(fairness)

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QoS WiFi

Principles of our approach: the QoS-WiFi

Predictible and controled performance:

→ define strict **priority classes**

→ define service classes **sharing fairly** the bandwidth.

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A compatible mode to present WiFi implementations:

- take the **strict control** of the chanel for a limited time, by signaling QoS packet as a PIFS mode.
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A patent has been filled on those mechanisms (january 2008).

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$$\Rightarrow \quad u_{n+3} = u_{n+2} + u_{n+1} + u_n$$

The number of valid sequences

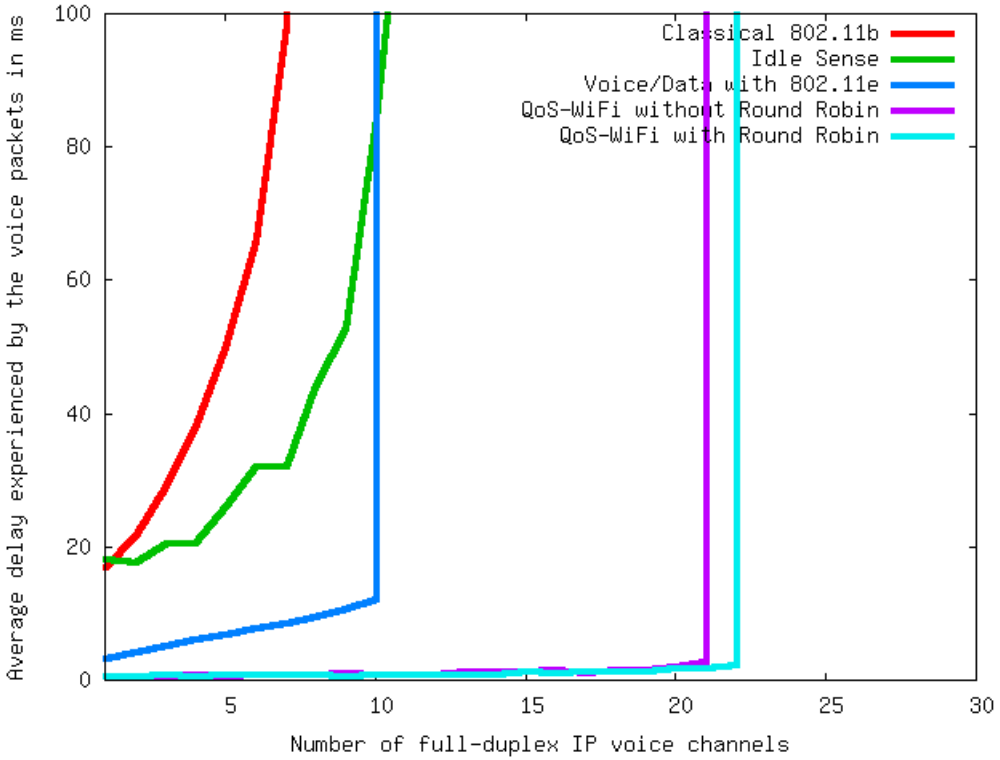
We have

$$u_n = \frac{16+8\delta+9\delta^2+2\delta^3+\delta^4}{3(16+4\delta^2+\delta^4)}\left(\frac{1}{3}+\frac{4}{3\delta}+\frac{\delta}{3}\right)^n + Re\left[\frac{1}{6}\left(\frac{32-8\delta+3\delta^2-2\delta^3+2\delta^4}{16+4\delta^2+\delta^4}+i\delta\sqrt{3}\frac{32-20\delta-5\delta^3+2\delta^4}{64-\delta^6}\right)\left(\frac{1}{3}-\frac{2+2i\sqrt{3}}{3\delta}-\frac{\delta-i\delta\sqrt{3}}{6}\right)^n\right]$$

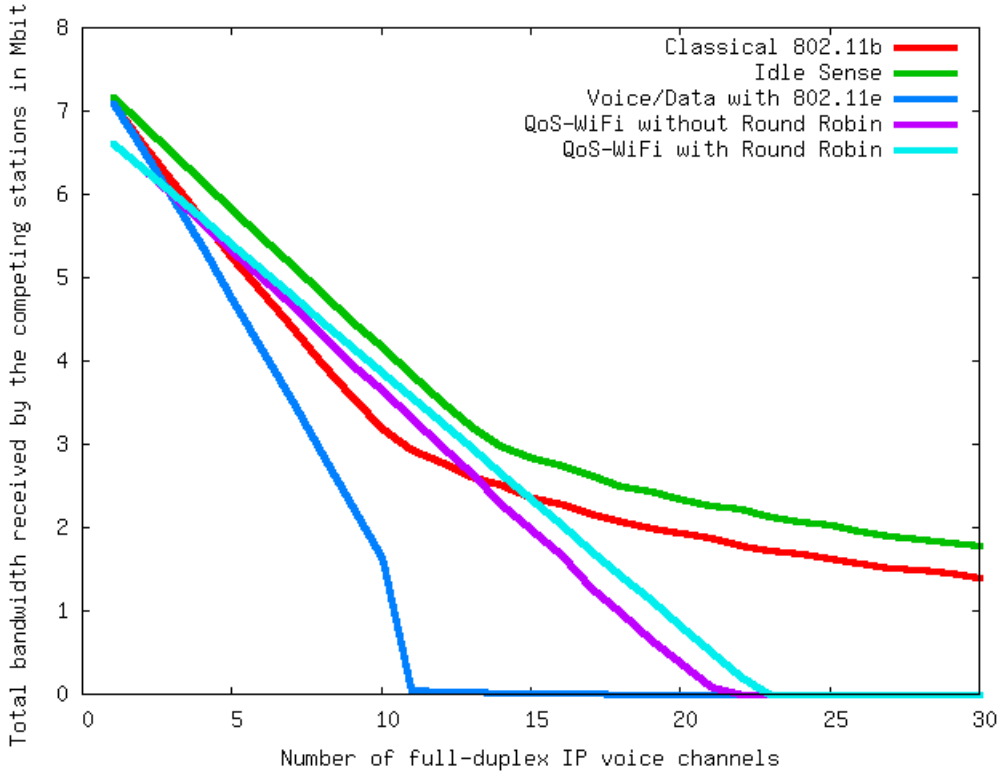
with $\delta = \sqrt[3]{19+\sqrt{297}}$.

and $u_n \approx 1.8392^n$.

Results by simulation on the QoS

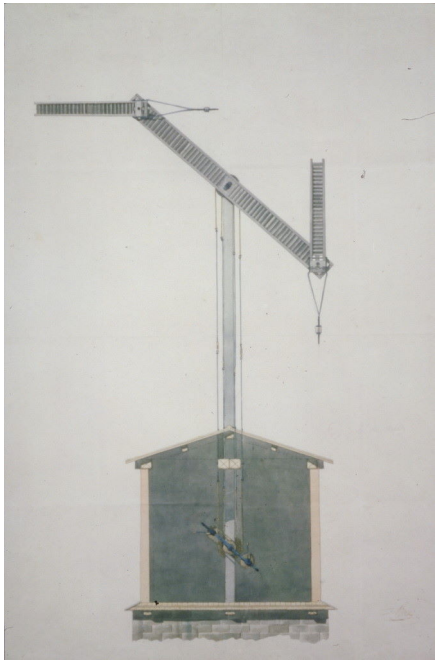


Circuit delays



Remaining bandwidth

Thanks for your attention!



Chappe, 1793

Bell, 1877

Ericsson, 1930

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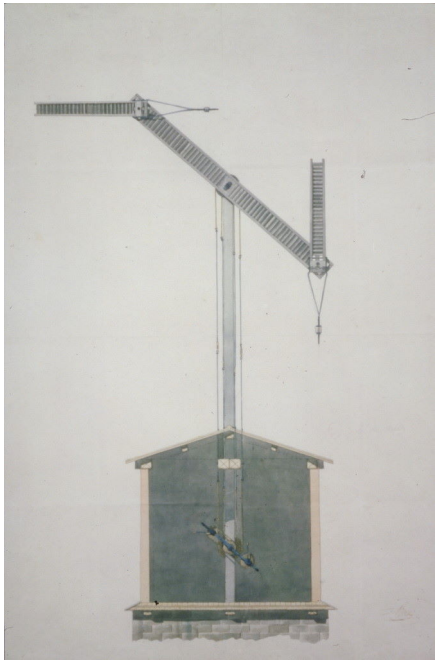

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