MICS
Mobile Information and
Communication Systems

A Power Independent Detection (PID) Method for Ultra Wide Band Impulse Radio Networks

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OUTLINE

- Introduction
- Conventional Synchronization Method
- Our Proposal: Power Independent Detection (PID) Method
- Concurrent transmissions using the same code
- Conclusions

Motivation and Objectives

Why a new detection method?

✓ To achieve ***pulse level*** synchronization for UWB-IR systems in the presence of ***inter user interference*** (IUI), in particular we deal with ***Near-Far problem***.

✓ Such scenarios occur mainly in uncoordinated systems, as it is proposed for some low bit rate low power networks.

✓ Even in coordinated systems, the ***inter user interference*** appears in the presence of multiple interfering piconets.

✓All the work in the literature considers either the absence of the ***inter user interference*** or its presence but with equal transmission power.

What about transmissions using the same time hopping code?

We use our proposal to investigate this case that arises in:

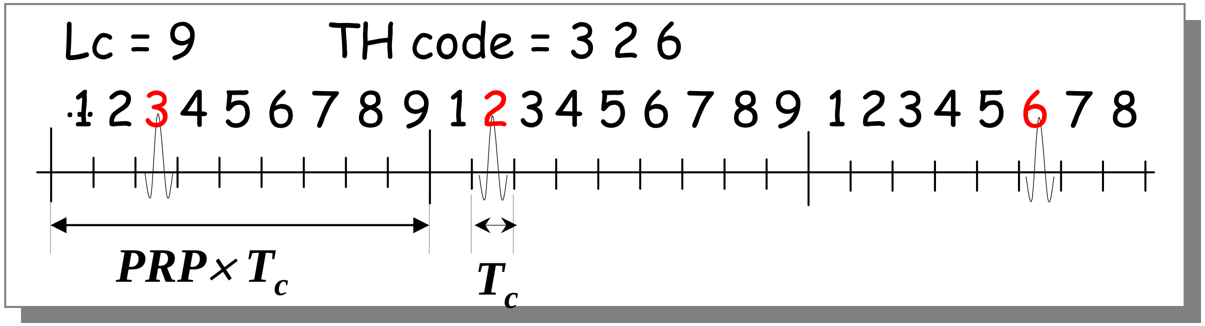
✓ Broadcast or control channels, e.g. $(UWB)^2$

✓ Competetion to the same destination, e,g, DCC-MAC

Physical Layer and Preamble Structure

Physical Layer:

✓ Common for all IR modulation schemes: BPSK, PPM,…

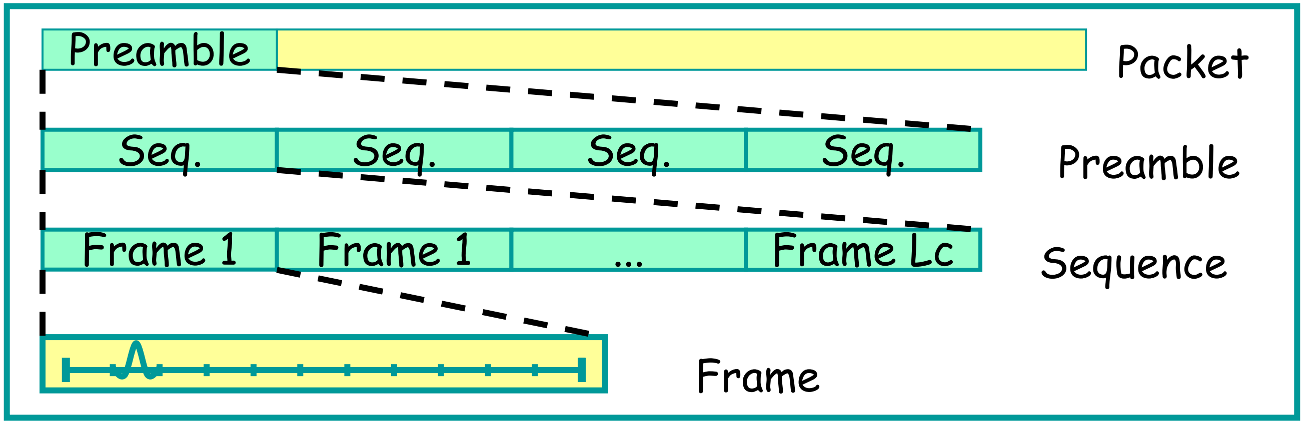


✓We do not consider any modulation for the preamble.

✓ Each user is identified by its unique TH code that determines the pulse positions in the frames.

✓ We consider the second derivative of the Gaussian pulse.

Preamble Structure:



✓ Preamble: periodic sequence of frames.

✓ The number of frames in the seq. Defines the code length Lc.

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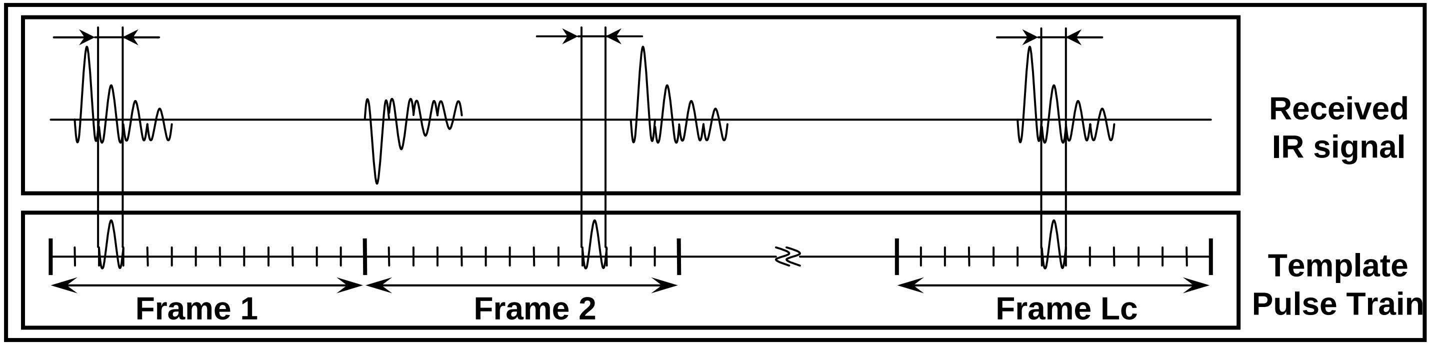
Conventional Synchronization Methods

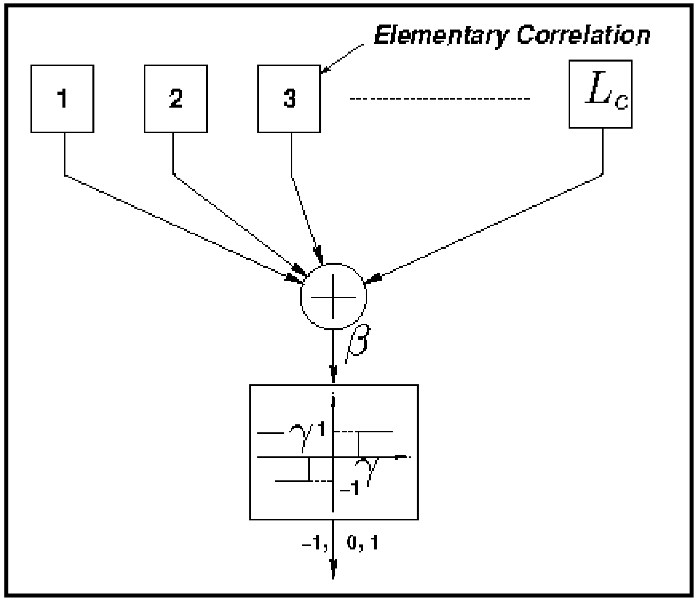
➪ It involves 2 ingredients: 1- Detection and 2- search algorithm.

1. Conventional detection method:

- The receiver knows the transmitter code, i.e. the seq. structure
- It generates a replica of the seq., which we call the Template Pulse Train (TPT)
- It applies a *correlation* (coherent integration) between the received IR signal and the TPT followed by a *threshold check*.

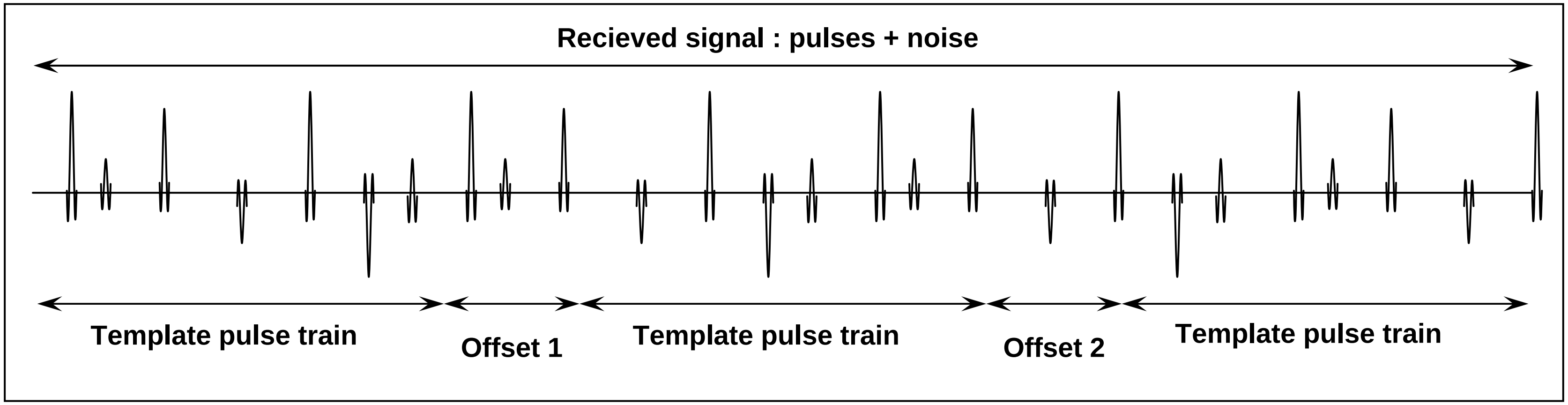


The correlation can modeled as Lc elementary correlations

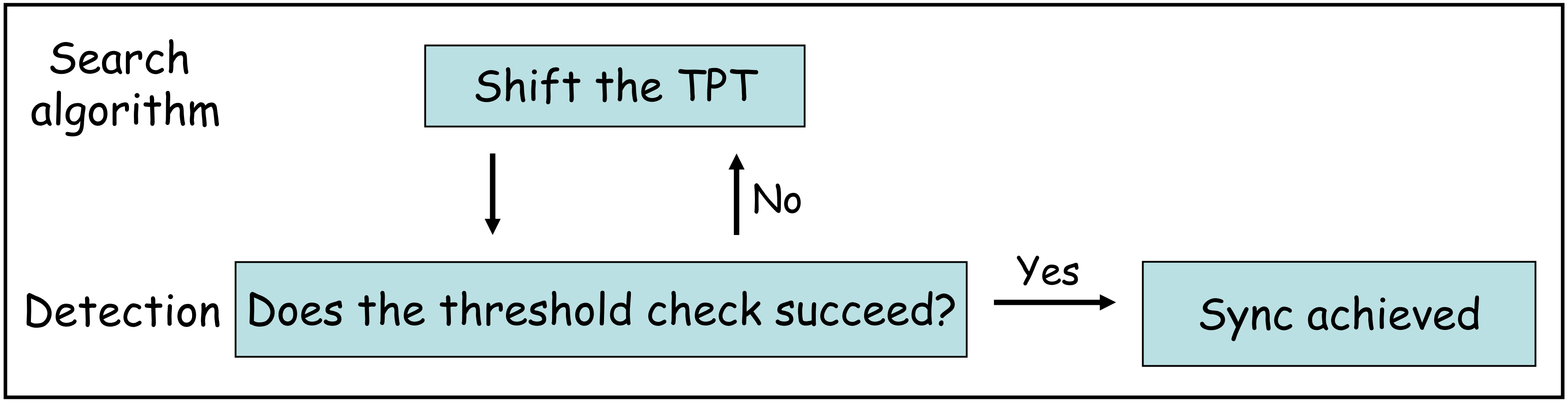


Conventional Synchronization Method

2. *Search algorithm:* which shifts the TPT. Shifting aims to cover all combination between TPT and IR signal (e.g. serial search, look and jump K).



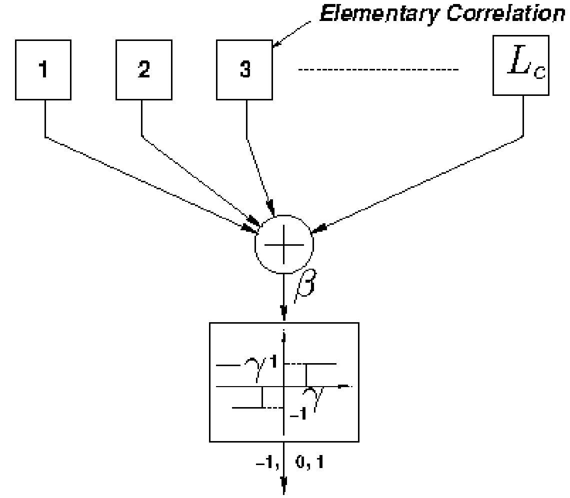
⇨ **Interaction between Detection and Search Algorithm**



Shortcoming of the Conventional Detetcion Method

Failure in the Near-Far scenario:

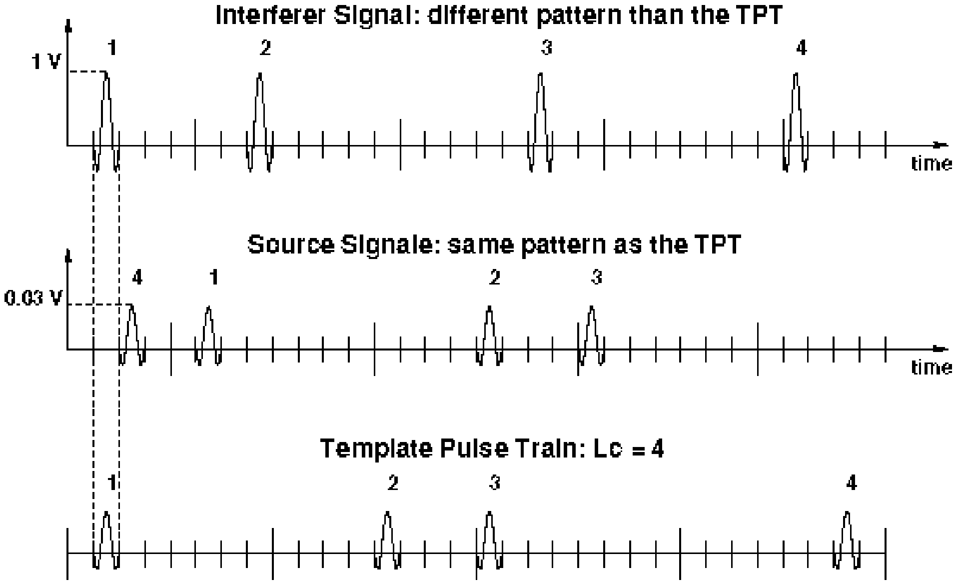
The parasite in one elementary correlation corrupts all the results



Failure example Based on measures done in [Win97]:

- ✓ The source is 10m away.
- ✓ An interferer is 1m away.
- ✓ Indoor environment.
- ✓ Source pulse amplitude: 0.03V
- ✓ Interferer pulse amplitude: 1V.

To detect the source: $\gamma < Lc \times \alpha_0$, ($Lc = 4$), α_0 = output of the correlation of one source pulse with one TPT pulse.



The correlation between one interferer pulse and one TPT pulse = $33x\alpha_0 > \gamma$ ==> False Alarm

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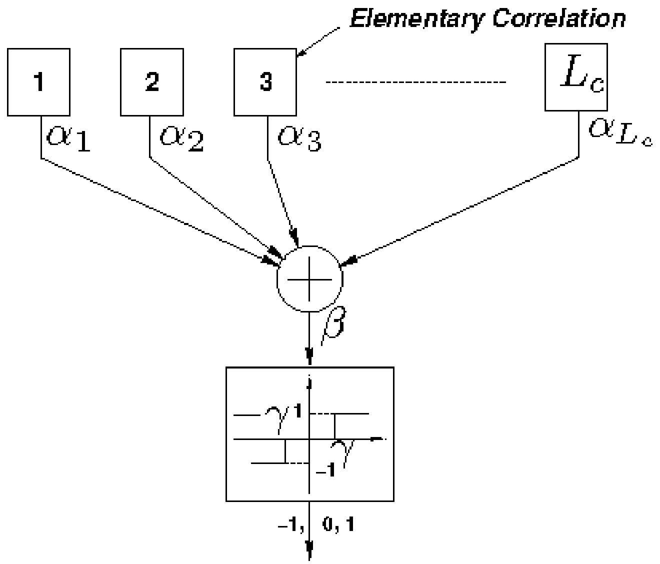
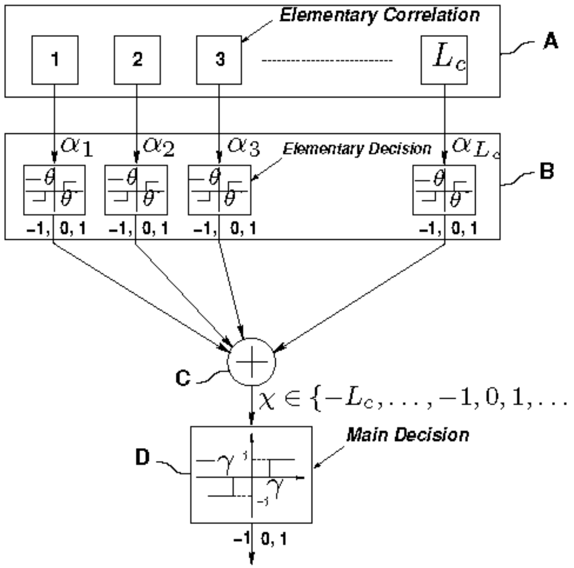
Our Proposal: Power Independent Detection (PID) Method

Conventional Detection Method



1. The outputs of the elementary correlations are summed together.
2. Main decision is based on the gathered energy from the elementary correlations.
3. A strong parasite in one elementary decision pollutes all the results.

PID Method



1. The outputs of the elementary correlations pass through elementary decision blocks that decide about the existence of pulses, then the digitalized outputs are summed.
2. Main decision is based on the number of pulses detected.
3. A strong parasite in one elementary decision is minimized by the elementary decision.

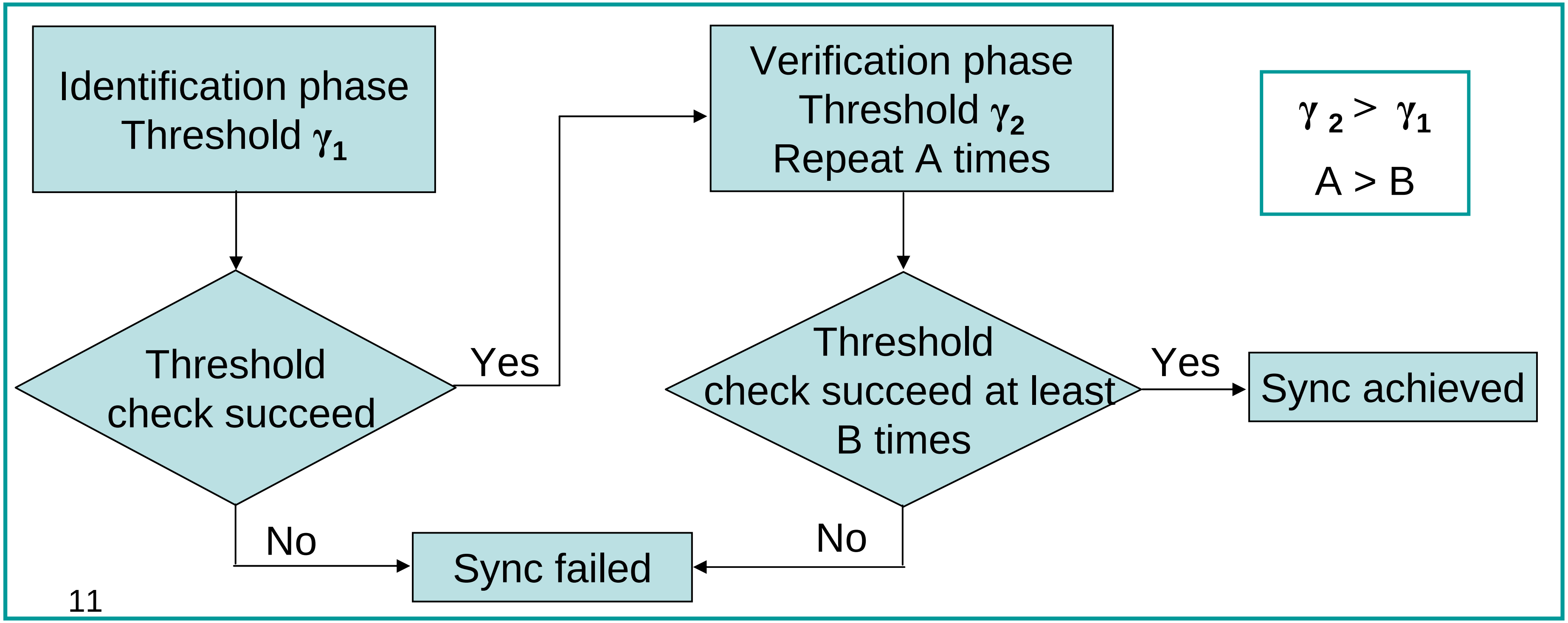
Performance Evaluation of The PID Method

- ✓ The conventional and PID method are embedded in a complete synchronization method.
- ✓ The complete synchronization method involves 2 phases:

  1- Identification phase. 2- Verification phase.

- ✓ Each phase contains both ingredients:

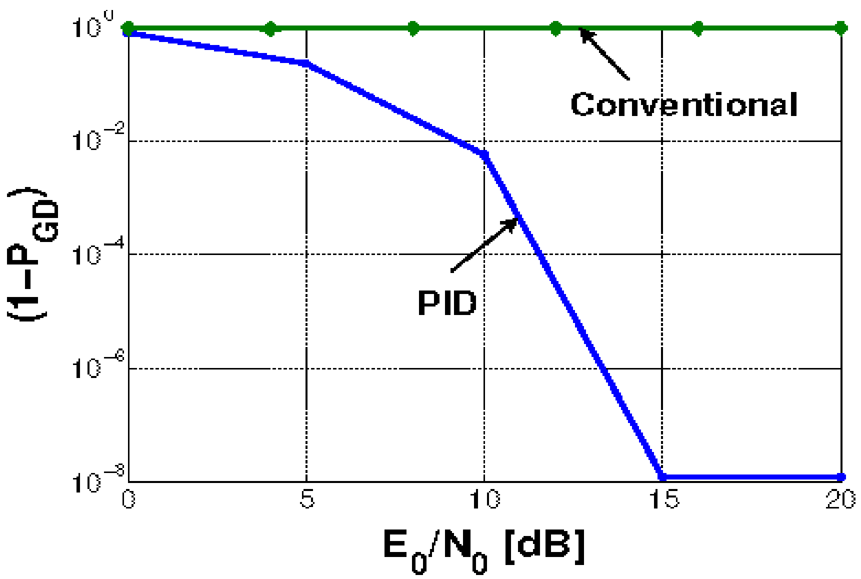
  1- Detection (Conventional or PID) 2- Search algorithm (Serial search).



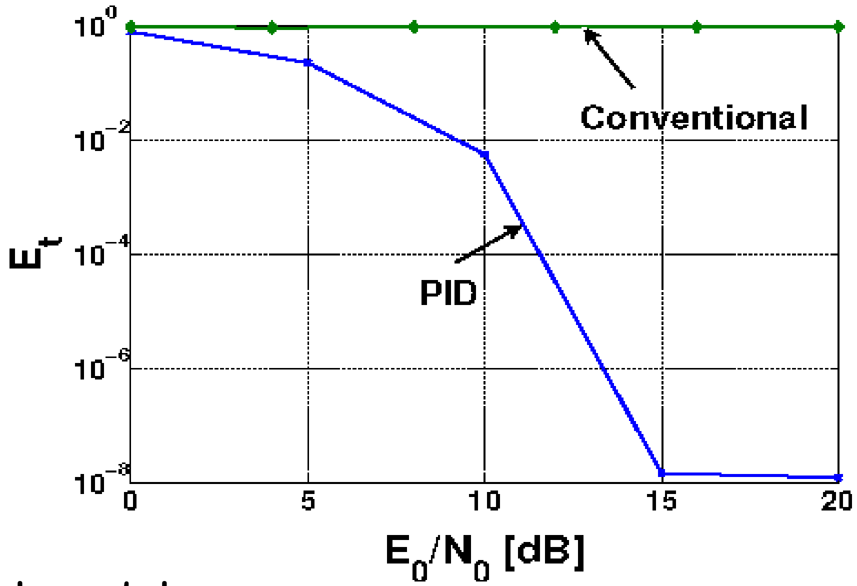
Performance Evaluation of The PID Method

The PID method outperforms the conventional method

1 – Proba of Good Detection



Total Error: missing the signal + False Alarm



✓ 802.15.4a indoor LOS *Multipath* channel model.

✓ Tc = 0.2 ns, Nc = 200 chips (40 ns), guard time of 100 chips.

✓ *Near-far scenarios:* the source is the furthest one (-30 dBm). Interferer powers are uniformly distributed over [-30, -10] dBm (range equivalent to 17 m)

✓ 10 users, Lc = 20

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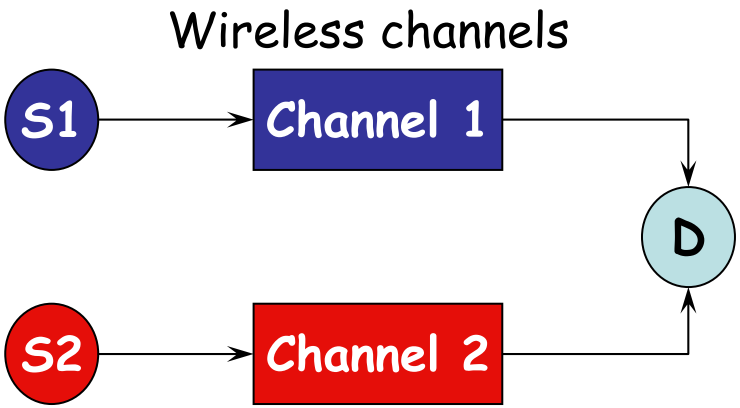
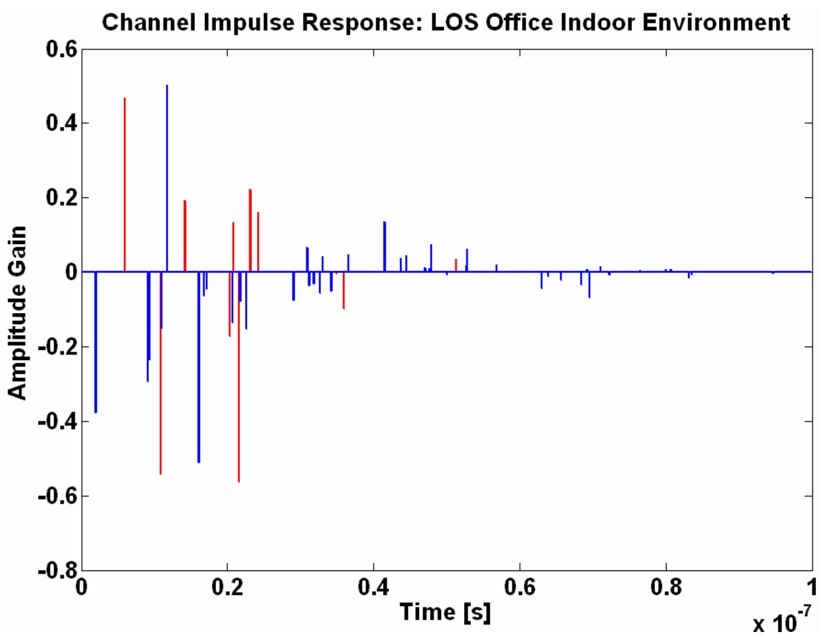
Concurrent Transmissions with the Same Code



Channel 1: $$h^{(1)}(t) = \sum_{l=1}^{L_1} a_l \delta(t - t_l)$$

Channel 2: $$h^{(2)}(t) = \sum_{k=1}^{L_2} a_k \delta(t - t_k)$$



- ✓ Each transmission encounters different multipath pattern
- ✓ Not all multipath components of the patterns collide
- ✓ The source is able to resolve one multipath component that does not collide with another.

Concurrent Transmissions with the Same Code

✓802.15.4a indoor LOS *Multipath* channel model.

✓ Sources are uniformly distributed within a range of 17 m ➔ receiving signals are with *different power levels*.

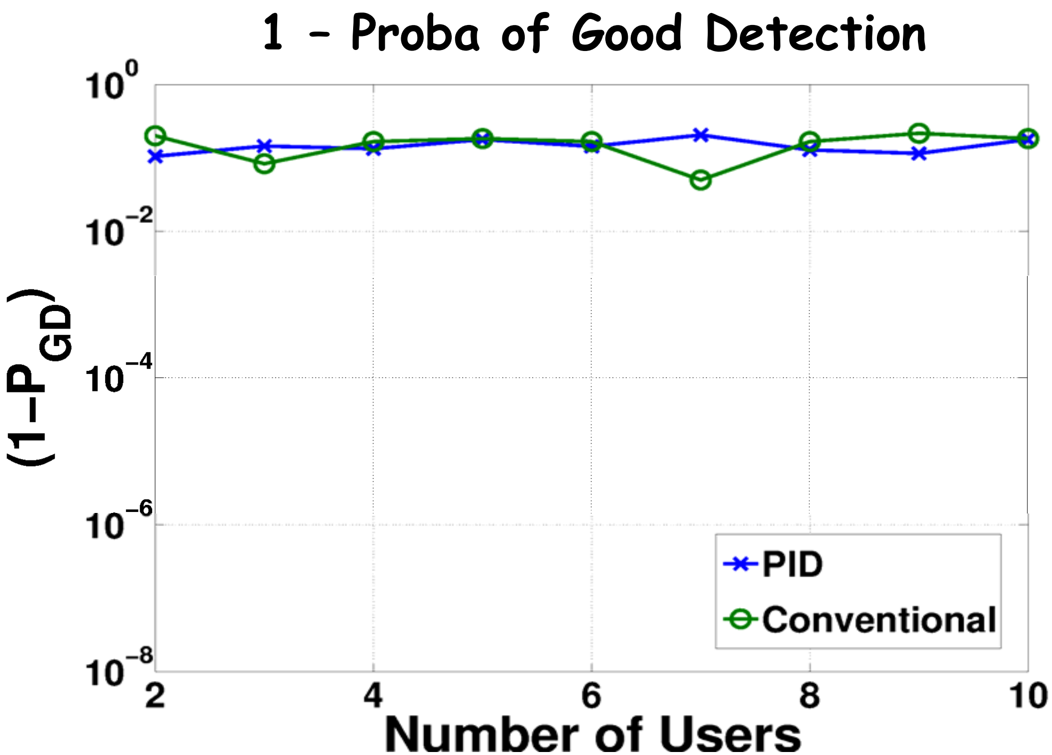
✓ E0/N0 = 15 dB with respect to the furthest source.

✓ Code length = 20

➢ With the PID method, detection is independent of the source power.

➢ With the conventional detection method, always the source with the highest power is detected

$P_{GD} > 0.9$



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Conclusions

✓ This was the *first work* that identifies the shortcoming of the conventional detection method in presence of concurrent transmissions with heterogeneous power level.

✓ We propose a new detection method that we call PID method.

✓ We evaluate the PID method: ***The PID method outperforms the conventional method***

Then, using UWB IR, we can envisage ad hoc network structures with simultaneous asynchronous transmissions without referring to any coordinator or centralized scheme.

✓ We continued this work and tested the case of concurrent transmissions with the same code and we could show that, with high proba (> 0.9), such transmissions do not result in collision.

✓ Hence, ***random access in UWB-IR systems using the same code can not be modeled as an Aloha scheme*** and further it performs much better.

Thank You