

Industrial Project 10

Designing a Wireless Interrogation System Enabling
the Tracking of Small Laboratory Animals

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—
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—
TIRO-MATOs

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Outline

1 Introduction

2 Overview

3 Accomplished work

- Architecture proposals
- Methods of calculation
- Integration of Java Software

4 Project Management Tools

- Wiki Space
- Gantt Chart

5 Conclusion

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Introduction

- Real-time position tracking
- Project tutored by LEAT and TIRO-MATOS
- RFID Concept and Antennae Communication studying
- Java Programming

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1 Introduction

2 Overview

3 Accomplished work

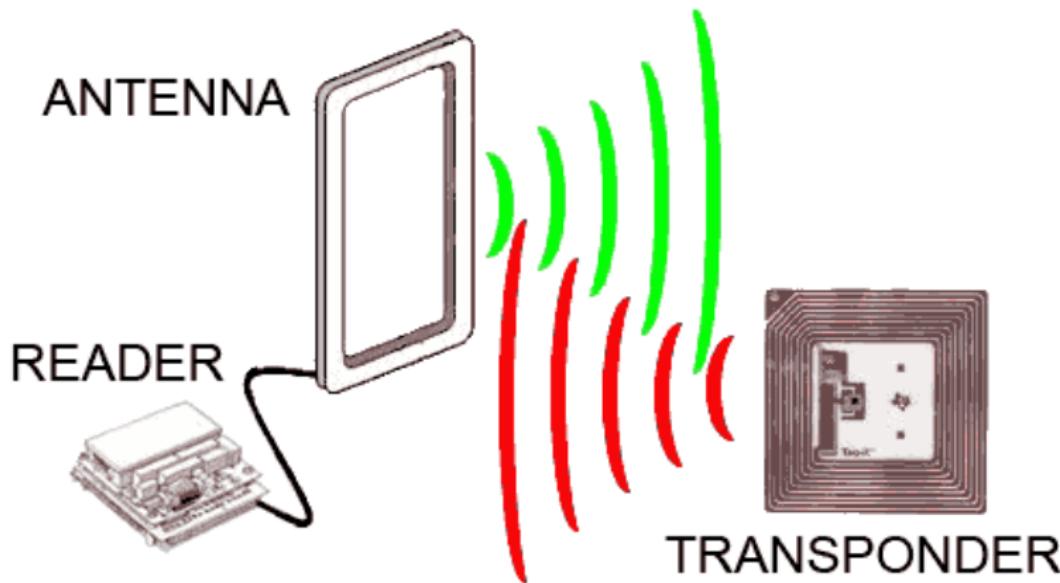
- Architecture proposals
- Methods of calculation
- Integration of Java Software

4 Project Management Tools

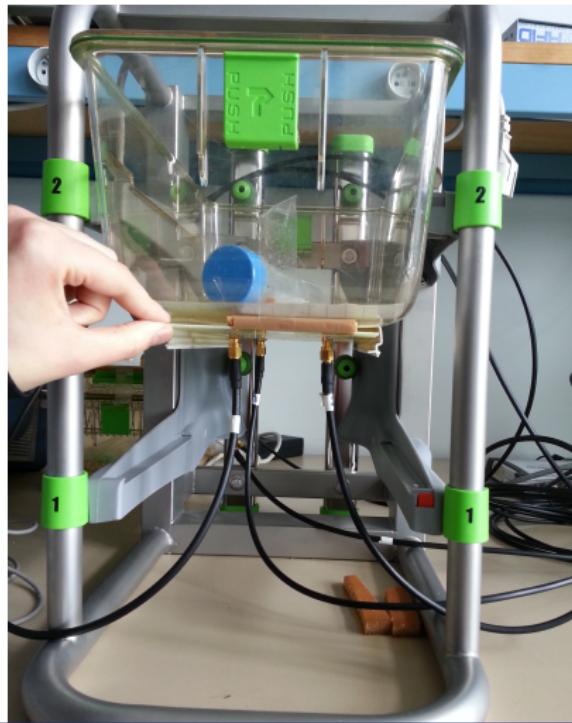
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- Gantt Chart

5 Conclusion

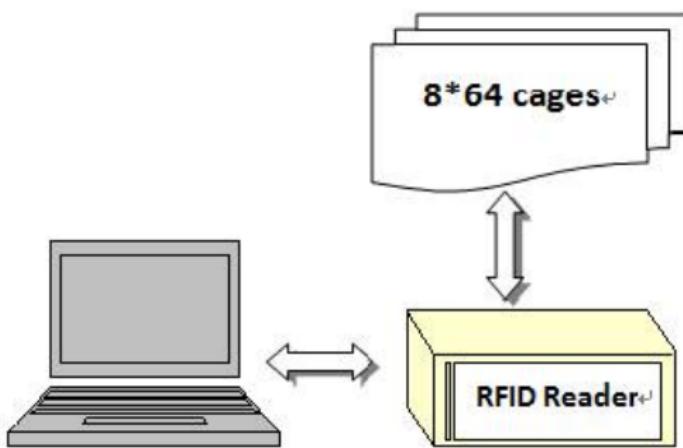
What is RFID ?



The Application of RFID in our project



Global Architecture



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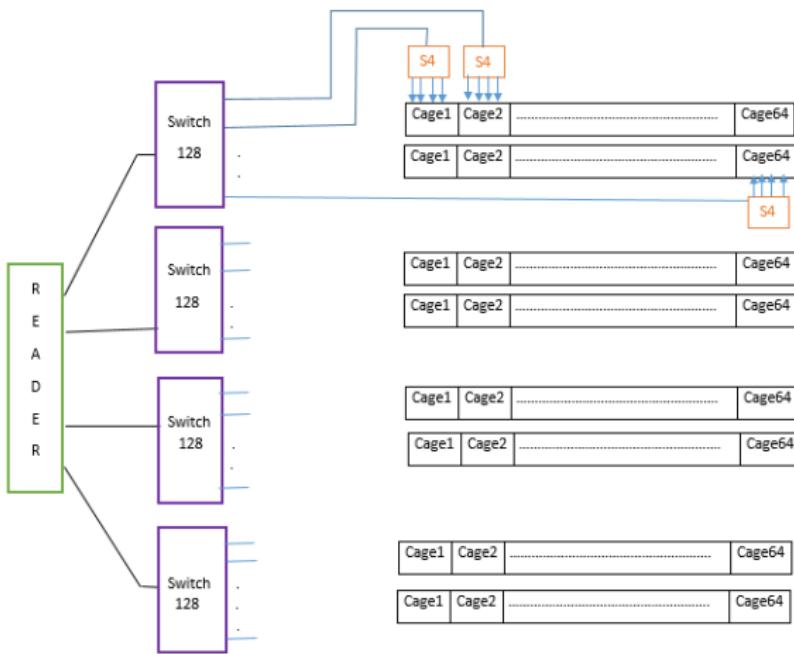
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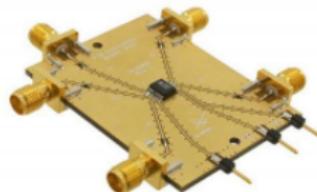
Architecture proposals

The First Architecture : Sequential

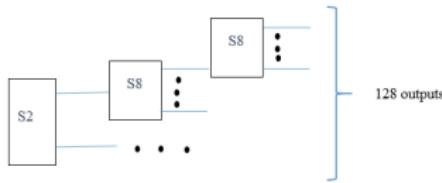


Sequential Architecture : Components

- The 4-output switch



- The 128-output switch



Sequential Architecture : Benefits and Drawbacks

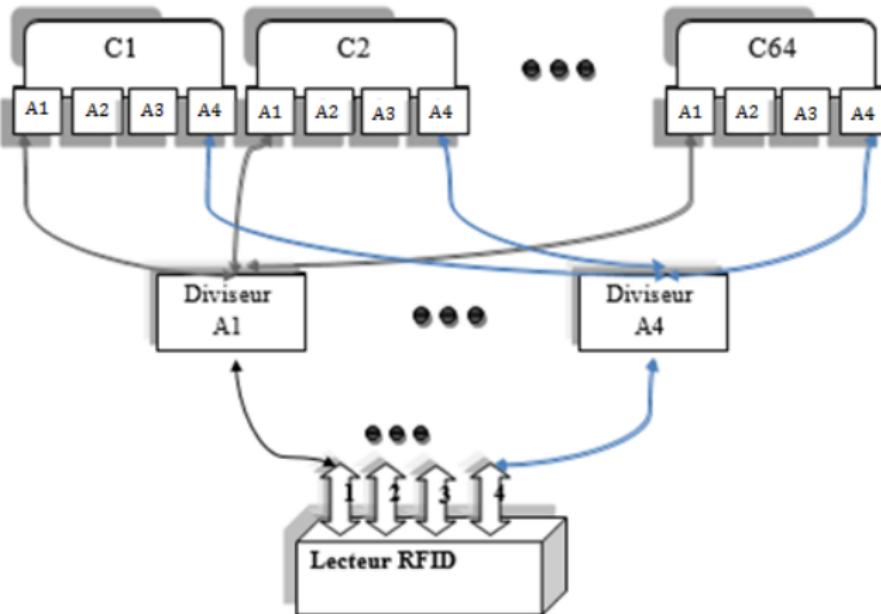
Benefits

- Automatic cage number identification

Drawbacks

- A significant time for receiving data
 - Excessive wiring and multiple switches

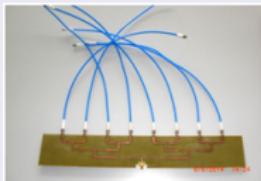
The Second Architecture : Parallel



Parallel Architecture : Components

Parallel architecture

- Amplifiers to supply the antennae at the same time
- A single RFID reader for the whole system
- Adapted dividers
 - ⇒ Dividers made by LEAT



Parallel Architecture : Benefits and Drawbacks

Drawbacks

- Manual registration of both the ID Tag and its corresponding cage number is required

Benefits

- Simultaneous inspection of all the cages
- Reduced complexity of the circuits
- Flexibility in changing the number of cages

First method : Context set-up

According to Friis Transmission Equation, the power received by an antenna in the cage is given by :

$$P_R = \sigma \frac{(\lambda * G)^2}{(4\pi)^3 d^4} P_I \longrightarrow P_R = \frac{k}{d^4}$$

σ : *Radar cross section*

λ : *Wavelength (m)*

G : *Antennae gains*

d : *Distance between tag antenna – cage antenna (m)*

Methods of calculation

First method : Algorithm for the calculation of the position

Algorithm

- For each combination of 3 antennae : Ratio of powers received by the antennae in pairs
- 2 quadratic equations of 2 unknowns (x_s, y_s)
- 12 possible combinations \Leftrightarrow 24 possible solutions
- The mean of all solutions

Constraints

- Non linear relation between Pr and d
- k depends on the type of the antennae

Methods of calculation

First method : Mathematical Application

- The powers received by the antennae A_i, A_j, A_l are given by :

$$P_i = \frac{k}{d_i^4}$$

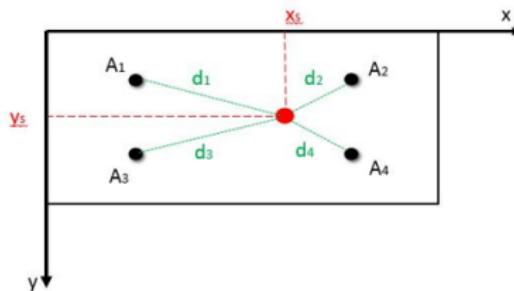
$$P_j = \frac{k}{d_j^4}$$

$$P_l = \frac{k}{d_l^4}$$

$$\sqrt{P_i} * d_i^2 = \sqrt{P_j} * d_j^2$$

$$\sqrt{P_i} * d_i^2 = \sqrt{P_l} * d_l^2$$

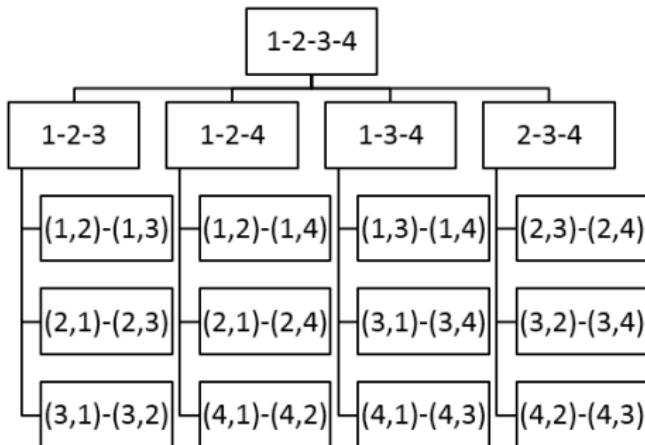
$$\begin{cases} \frac{x_i^2 + y_i^2}{\sqrt{P_j}} = \frac{x_j^2 + y_j^2}{\sqrt{P_i}} \\ \frac{x_i^2 + y_i^2}{\sqrt{P_l}} = \frac{x_l^2 + y_l^2}{\sqrt{P_i}} \end{cases}$$



- $x_i, x_j, x_l, y_i, y_j, y_l$ are given as functions of x_s et y_s

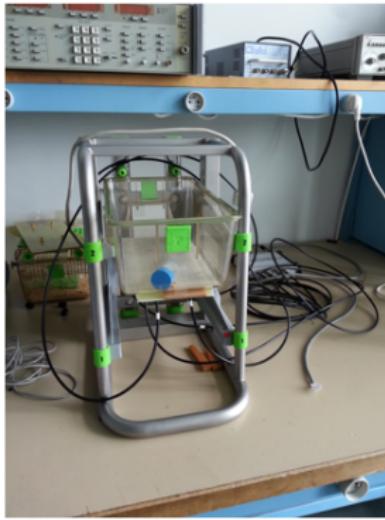
First method : Mathematical Application

- All possible combinations from 4 antennae are :



Methods of calculation

First Test of the Algorithm : Data acquisition

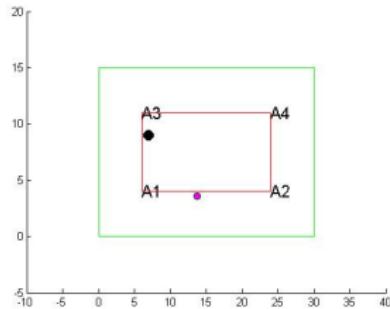


	Antenne 1	Antenne 2	Antenne 3	Antenne 4	
X5_Y2	-59,9257864	-69,317791	-67,5229701	-82	Antenne 1
X5_Y4	-62,0067467	-67,9643442	-65,3979286	-82	Antenne 1
X5_Y10	-63,5561717	-67,6232915	-60,5357724	-66,7612836	Antenne 3
X6_Y1	-59,7712821	-70,1230159	-72	-82	Antenne 1
X7_Y9	-54,2581211	-59,3091434	-61,2111302	-68,2909699	Antenne 1
X8_Y11	-53,9866375	-61,067429	-54,2770452	-62,8265078	Antenne 1

Methods of calculation

First Test of the Algorithm : Results

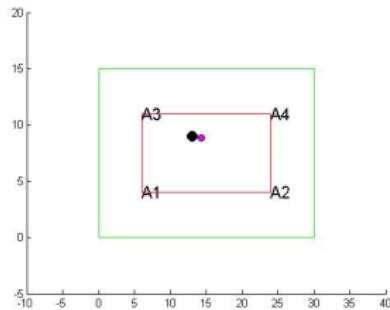
Position	Antenne 1	Antenne 2	Antenne 3	Antenne 4
X5_Y10	-63,5561717	-67,6232915	-60,5357724	-66,7612836
X7_Y9	-54,2581211	-59,3091434	-61,2111302	-68,2909699
X24_Y3	-66,7208886	-68,7898396	-65,8489114	-68,3328903
X13_Y9	-62,5526316	-59,5818713	-60,518018	-63,1750524



Methods of calculation

First Test of the Algorithm : Results

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First Test of the Algorithm : Analysis of the Results

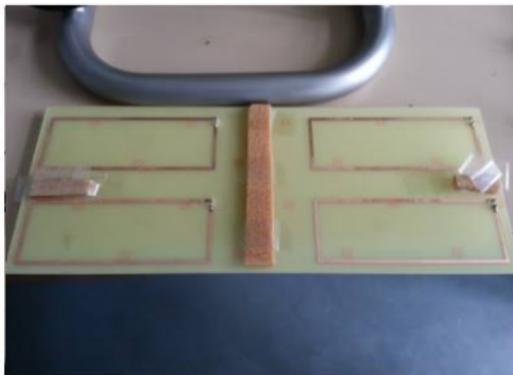
- Interpretation of the results

- Mismatching between measured and calculated positions
- Causes
 - ⇒ The reader lacks of sensitivity
 - ⇒ Some powers are not received
 - ⇒ Coupling problems between antennae

Methods of calculation

Second Test of the Algorithm : Modifications

- Modifications
 - A new RFID reader
 - Another type of antenna



Second Test of the Algorithm : Modifications

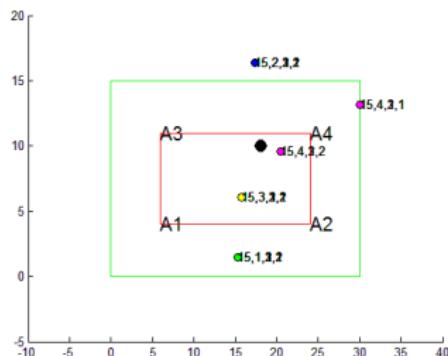
- Modifications
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Methods of calculation

Second Test of the Algorithm : Results

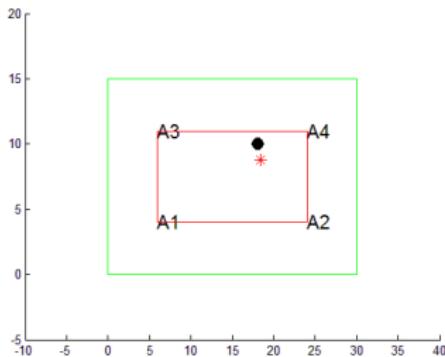
Real x	Real y	Calcd x	Calcd y	$\sqrt{\Delta x^2 + \Delta y^2}$
13	7	13.1927	4.6358	2.372040246
16	7	17.2885	9.655	2.951145074
25	10	18.4299	6.4041	7.48977375
25	9	18.6738	11.3821	6.75982299
26	3	16.5995	8.1278	10.70811529
8	11	12.5796	6.3479	6.527998971
14	7	12.2136	5.2184	2.522959278
11	12	15.107	7.6536	5.979853005
13	4	17.049	8.2011	5.834692983
5	2	14.5212	8.6764	11.62873881
14	7	14.1131	10.3099	3.311831762
14	10	13.51	5.0397	4.984443408
17	2	14.5747	8.155	6.615595596
18	6	14.4342	6.7489	3.643594496
21	2	14.9177	6.8701	7.791806421
22	3	16.7459	4.3596	5.427161226
22	8	18.6129	4.8518	4.624241522
23	12	16.5109	5.1866	9.409082759
23	12	18.1551	6.7086	7.174396837
24	3	14.3221	7.9924	10.88971102
24	4	19.0375	4.313	4.972361134



Methods of calculation

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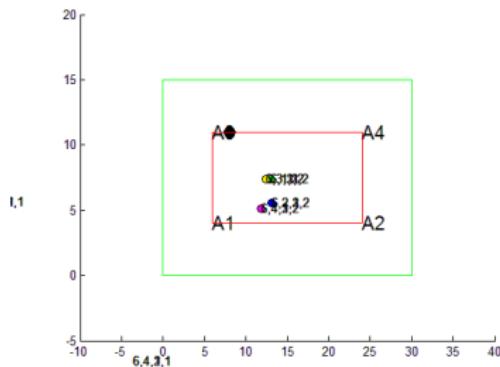
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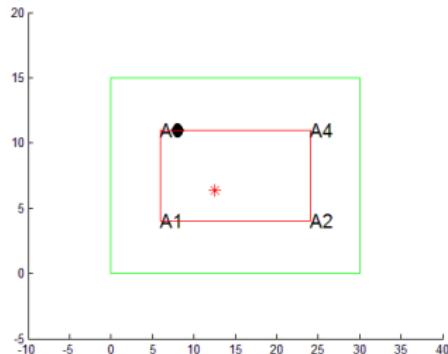
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Second Test of the Algorithm : Analysis of the Results

- 85 % of correct results when the tags are far from radiations of the antennae (with $\sqrt{\Delta x^2 + \Delta y^2} = 4.55$)
- For the tags that are too close to the radiation field : ($MSE = \sqrt{\Delta x^2 + \Delta y^2} = 8.89$)

Possible causes

- Near fields
- Physically, an antenna cannot be considered as a theoretical point in the plane
- Formula of Friis only available for far field

Considered Approaches

Artificial Neural Network

Second Method : Artificial Neural Network

Definition

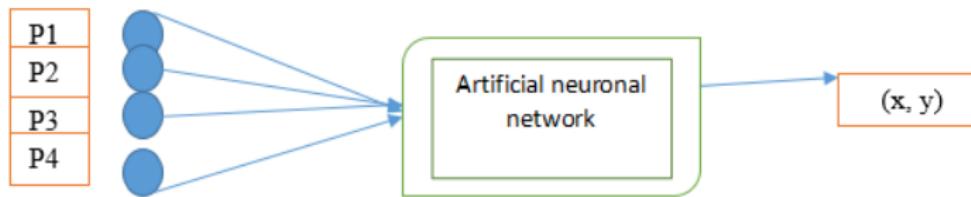
- A computational model
- Model inspired by animal's central nervous systems
- System of interconnected neurones : computes values from inputs

Why is it useful ?

- Ability to generalise and to respond to unexpected inputs

Second Method : Artificial Neural Network

- The Design



Different Steps

- Constructing a database based on power inputs
- Dividing the database into 2 parts (learning and validation)
- Creating our model

Second Method : Artificial Neural Network

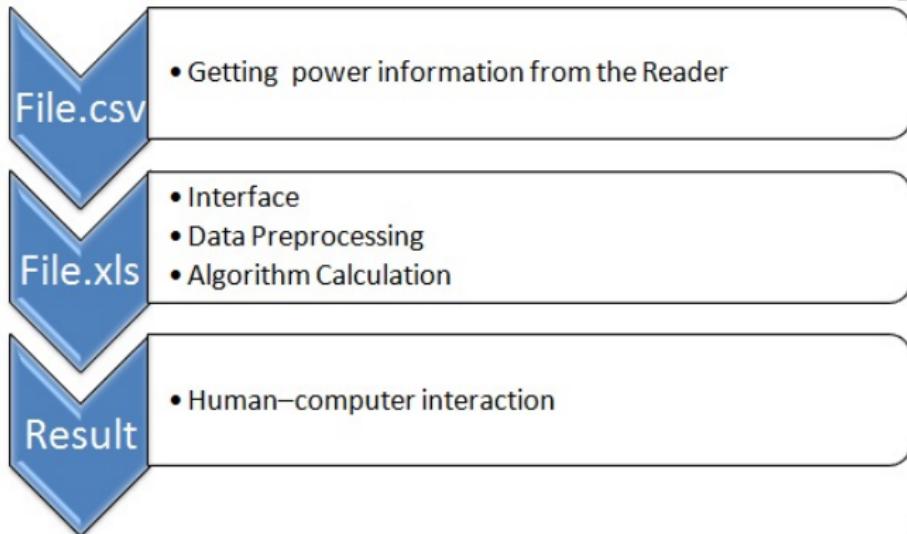
Minimum Mean Square Error

- Error between determined outputs and expected outputs
- MMSE = 219

Constraints

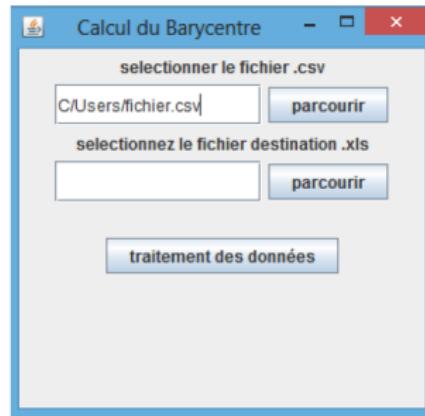
- A precise selection of the model must be done to get satisfying results

Java Software : Main Goals



Java Software : Creating a simple interface

- Providing an absolute path for power data file (.csv)
- Supplying a destination for the file containing the positions (.xls)
- Processing Data



Java Program : Formatting Data

Data preprocessing

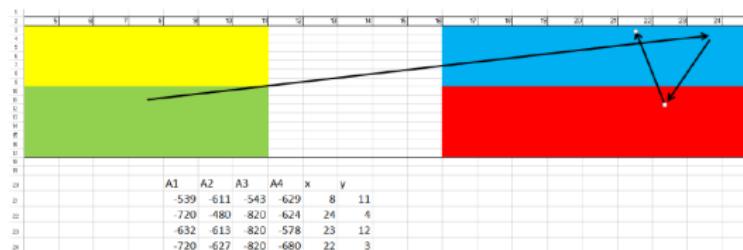
- Detecting a power each 150 ms
- Possibility to have some missing powers
- Solution : Missing powers fixed to -75 dBm

num souris	temps(ms)	niv de puiss(n° antennes
32385421	331	-704
32385421	459	-574
32385421	600	-720
32385421	754	-690
32385421	1050	-577
32385421	1348	-698
32385421	1637	-575
32385421	1945	-708
32385421	2235	-579
32385421	2539	-700

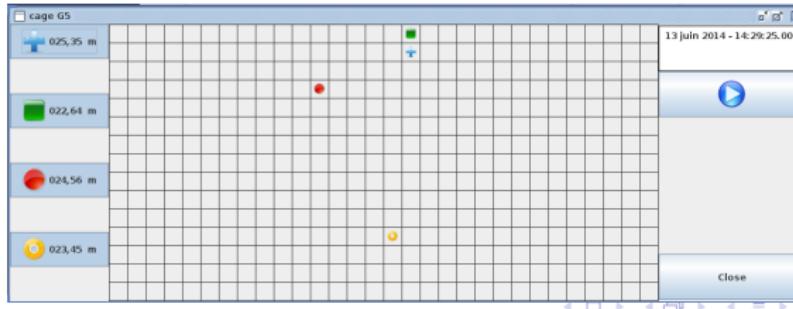
A	B	C	D
num_souris	temps(ms)	puis(10dbm)	num_anten
32385421	150	-750	1
32385421	300	-750	2
32385421	331	-704	3
32385421	459	-574	4
32385421	600	-720	1
32385421	754	-690	2
32385421	1050	-750	3
32385421	1200	-750	4
32385421	1348	-698	1
32385421	1500	-750	2

Human-computer Interaction

- Test case (Measured positions)



- Display of the positions in our interface



Human-computer Interaction

Demonstration

- Data Acquisition
- Data Processing
- Results on Human-computer Interaction
- VIDEO

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Project Management Tools : Wiki Space

Accueil Ma page Projets Aide

Connexion en tant que midrel Mon compte Déconnexion

Redmine

Recherche :

Aperçu Download Activité Roadmap Demande Nouvelle demande Années Wiki Forums Dépôt

Demandes

▼ Filtres Statut Ajouter le filtre

► Options

Appliquer Effacer Sauvegarder

#	Tracker	Statut	Sujet	Mis à jour	Catégorie
15900	Feature	New	Add to Issues List column of the attachment icon	2014-01-19 04:29	UI
15899	Feature	New	Cover All and Every Atlassian JIRA Feature	2014-01-18 22:05	
15886	Patch	New	Calculation of forecast dates between related tasks	2014-01-16 12:29	Issues
15885	Defect	New	Redirection of a wikidpage with a % sign seems to be broken	2014-01-16 11:40	Wiki
15881	Defect	Needs feedback	Using Roles::PermissionsAttributeCoder makes migration from 1.4 lose role permissions	2014-01-19 09:26	Permissions and roles
15880	Feature	New	Consistent, global button/menu to add new content	2014-01-18 17:24	UI
15878	Defect	New	Automatic line break on a numbered list should start the same position as the text before the line break.	2014-01-15 16:30	PDF export
15872	Defect	New	url_for causes routing problems if a plugin uses namespaces	2014-01-19 09:29	Plugin API

Demandes

Voir toutes les demandes Résumé

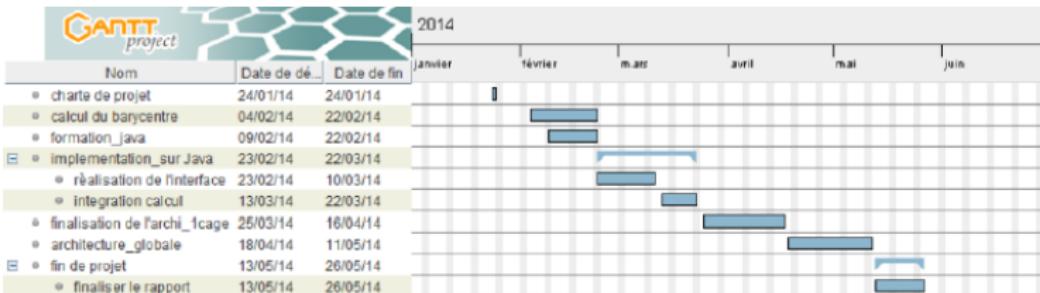
Rapports personnalisés

Documentation issues
Open defects
Open features
Plugin issues
Translation patches

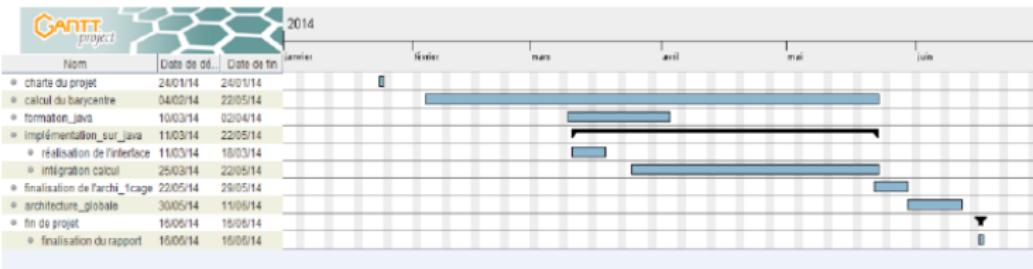
Gantt Chart

Project Management Tools : Gantt Chart

- First forecast chart

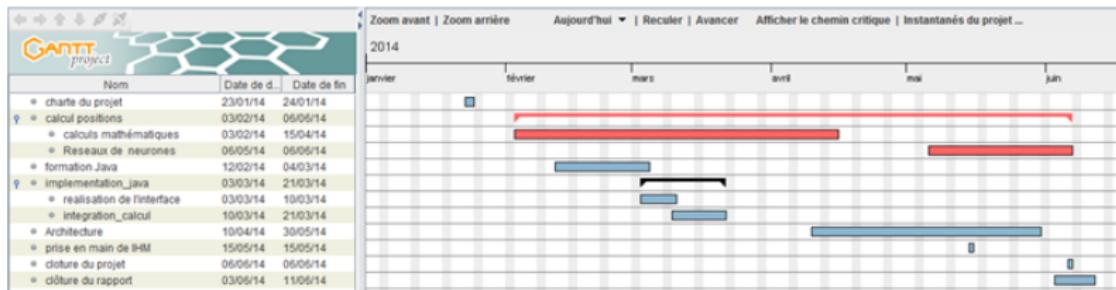


- Second forecast chart



Gantt Chart

Project Management Tools : Gantt Chart



Evaluation of Gantt Chart

- 90 % of work accomplished
- 80 % of the project requirements respected

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Perspectives

- Minimizing the MSE in the Artificial Neural Networks program
- Completing the interfaces of the Java softwares

Conclusion

- ➊ Project of innovation
- ➋ Skills acquired
 - ⇒ RFID System
 - ⇒ Further cognition regarding antennae
 - ⇒ Basic Object Programming
 - ⇒ Project management tools
- ➌ Practicing the knowledge acquired in a real project

Thanks for your attention !

