ELECTRICAL & ELECTRONIC ENGINEERING
STELLENBOSCH UNIVERSITY

Towards a smart environmental and cultivation monitoring system for sustainable crops

AGRINET

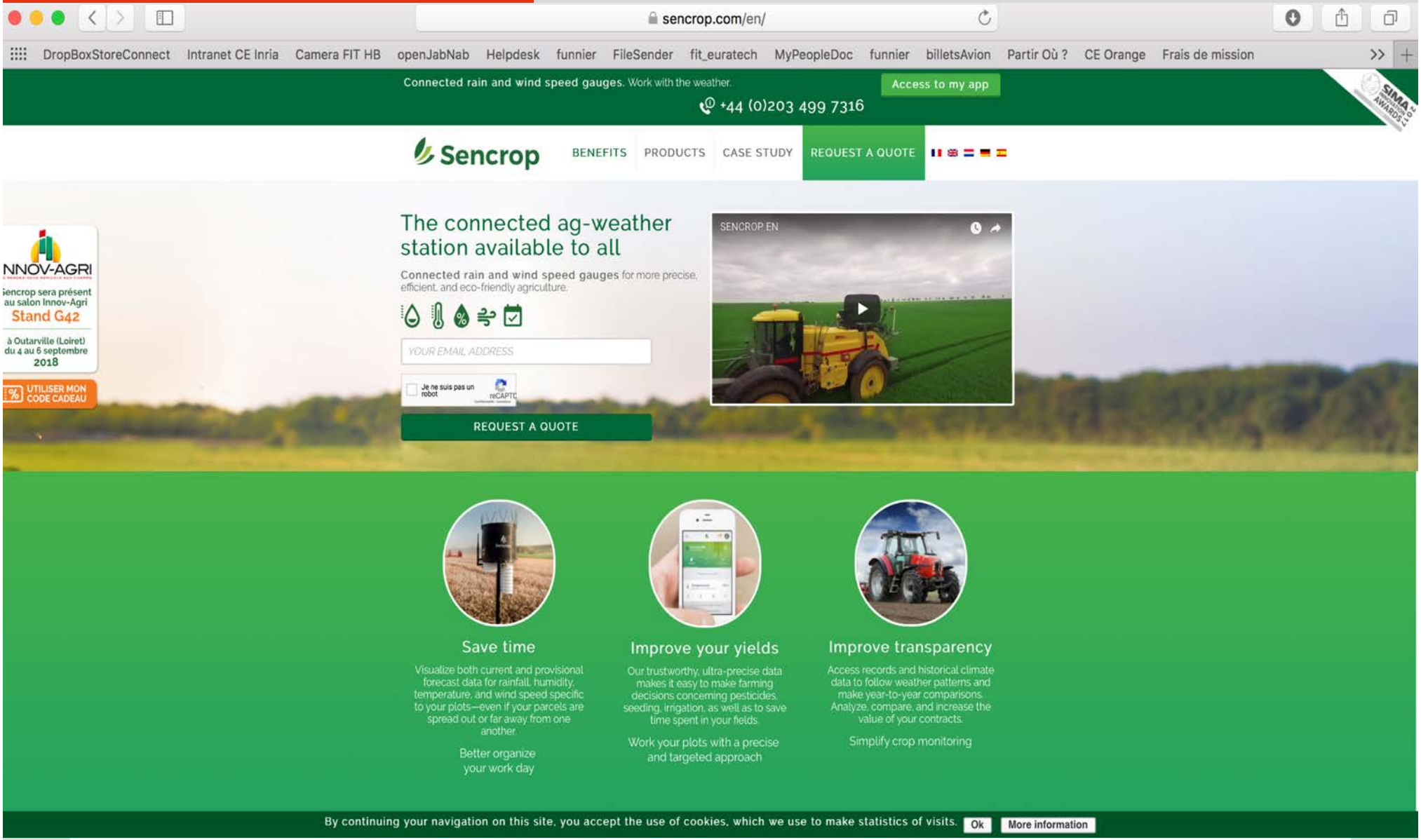
Context and motivations

- Both in France and South Africa, agriculture makes a huge economic contribution
- The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production.
- Sustainable food security depends upon proper plant and crop management respectful of soils and natural resources, such as water.
- **→ Agrinet proposes to study and deploy a WSN-based sustainable solution for better natural resources and crop management.**

AGRINET project

- A LIRIMA since January 2017 between
  - FUN team at Inria Lille
    - Nathalie Mitton and Valeria Loscri
    - Students: V. Toldov, A. Mbacke, C. Razafimandimby, B. Foubert
  - Stellenbosch University in South Africa
    - Department of Electrical & Electronic Engineering
      - R. Wolhuter and T. Niesler
      - Students: R Lùttich, J. Wotherspoon, D. Christians, S Vanasbroek, M. O'Kennedy
    - Department of Agrisciences
      - A. Strever, C Poblete
  - With the participation of:
    Sencrop company (www.sencrop.com) (France)
    Winetech Industry Research Support (www.wintech.co.za) (South Africa)

- Supported by the PHC PROTEA 2017 – 2018 program



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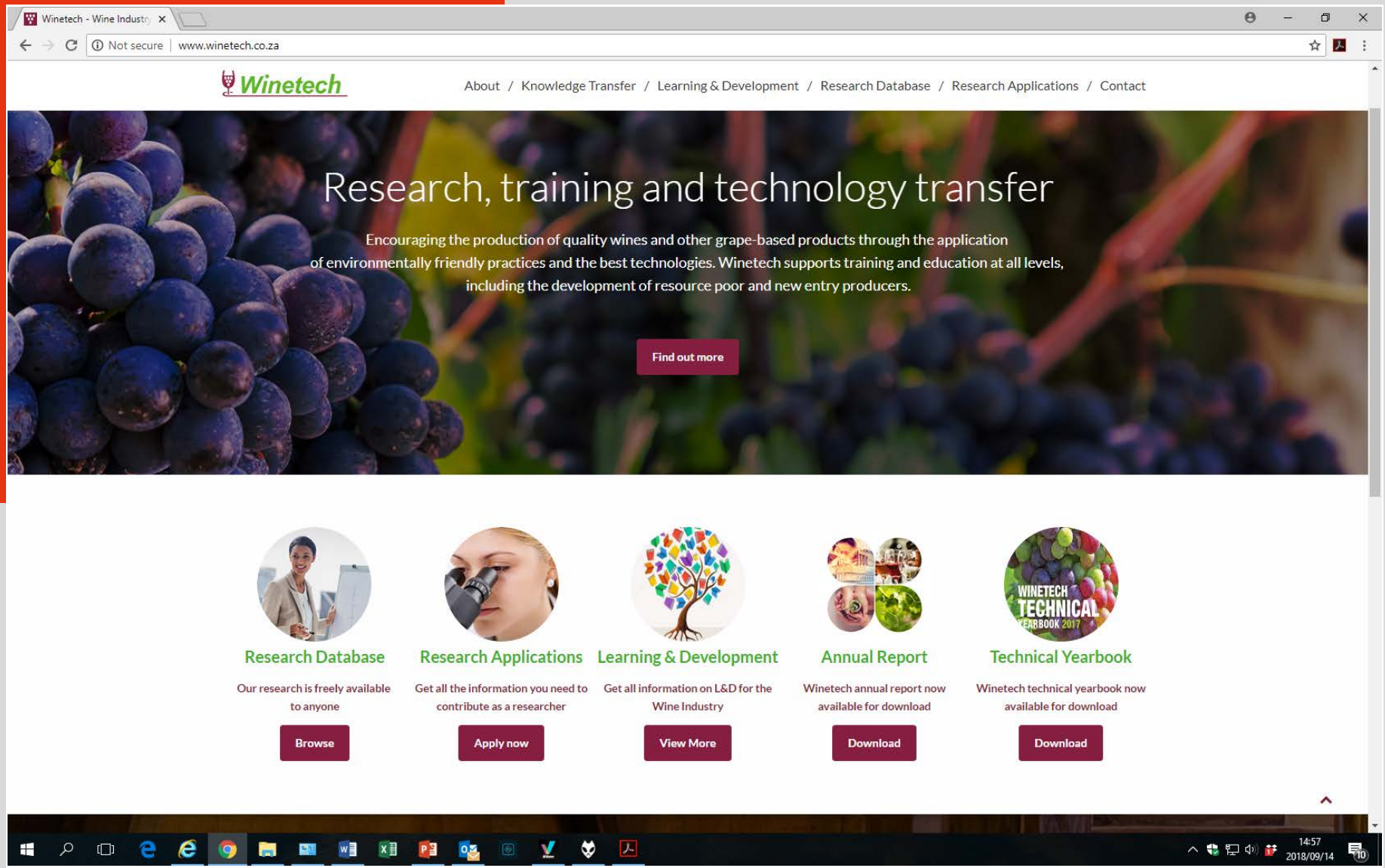

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AGRINET project (2)

- Adaptive Machine Learning based tools
- Continuous deep view of crop and soil status
- Identify different factors that impact on crops and allow optimal and easier culture and crop management
- Understand and Exploit the correlation between these different factors together with their time and space variability
- Anticipate crop disease

Realisation of two pilots (vineyards and potatoes)

Steps

- Wireless sensor design : (SU)
  - Small, low cost, robust, wireless (433/900 MHz preferred but open to other technologies)
  - Several embedded sensors (temperature, humidity, canopy moisture, pictures and spectral data, etc)

- Wireless communication protocols (Inria)
  - Adaptive , energy-efficient, reliable, multihop, multipath, multitechnology

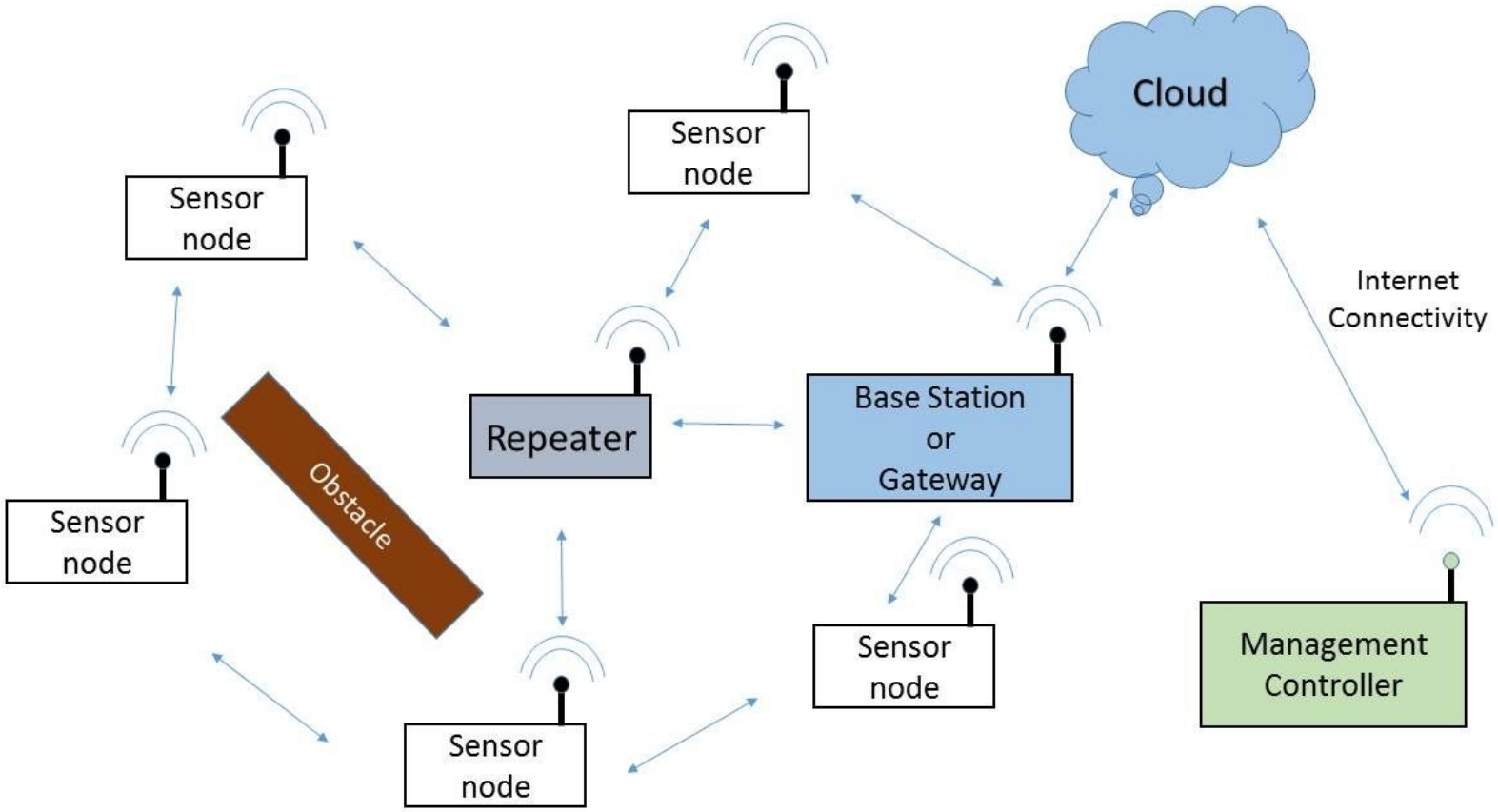
→Adapted to usage and climatic conditions

- Gateway node design with Internet connection. (Inria + SU)

- Machine-learning based algorithmic tools for decision-assistance tools (SU)

System Design

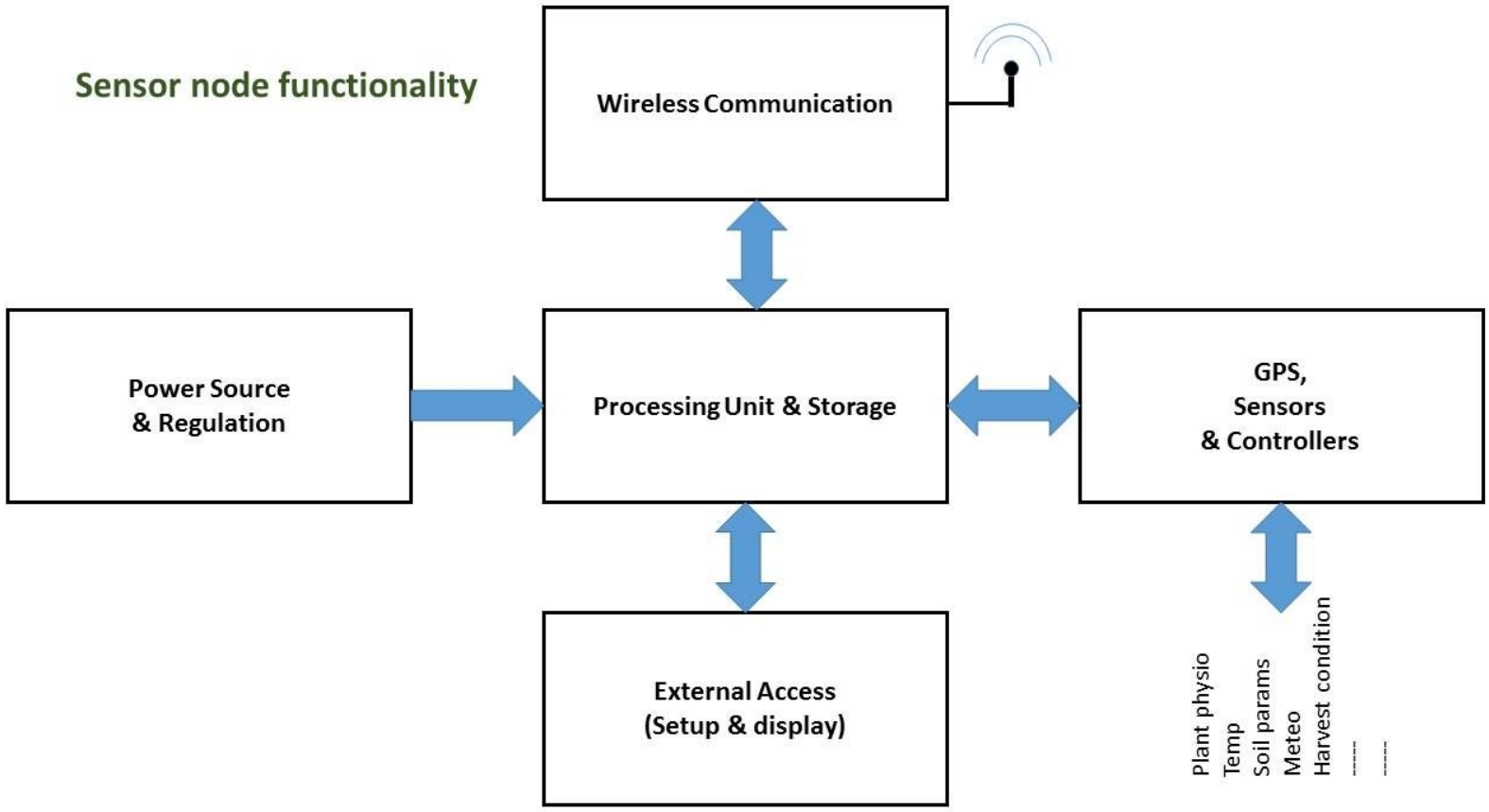
Typical WSN configuration:



Sensor network architecture

System Design

WSN Block Diagram



Progress

- System specifications defined
- Wireless sensor components identified and tested
  - NB 433MHz and LoRa
- First in-field tests realized for range validation
- Communication protocol
  - First basic version implemented
  - First basic multitechnology designed implemented and tested

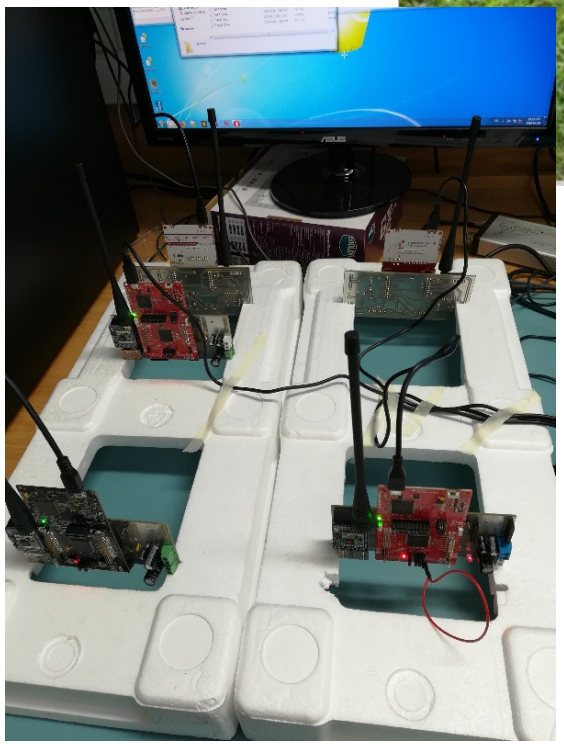
  → *More advanced versions under study, including error mitigation strategies*
- Development of first predictive algorithms tested with real datasets

  → For decision-assistance

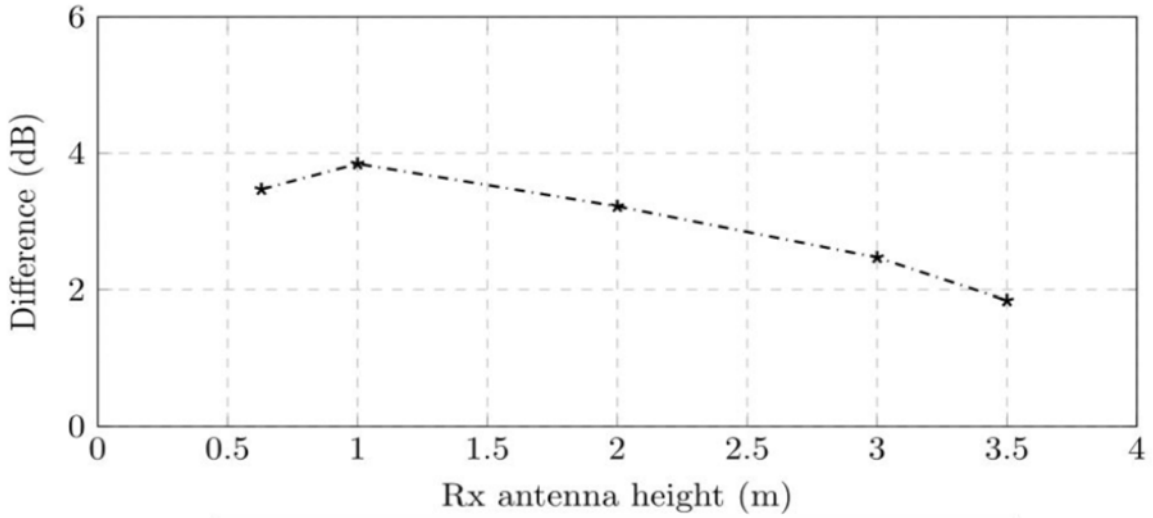
  → To reduce the quantity of data to send
- Actual power measurements on each transceiver to determine the true/real power output of each transceiver for a configured power output in progress

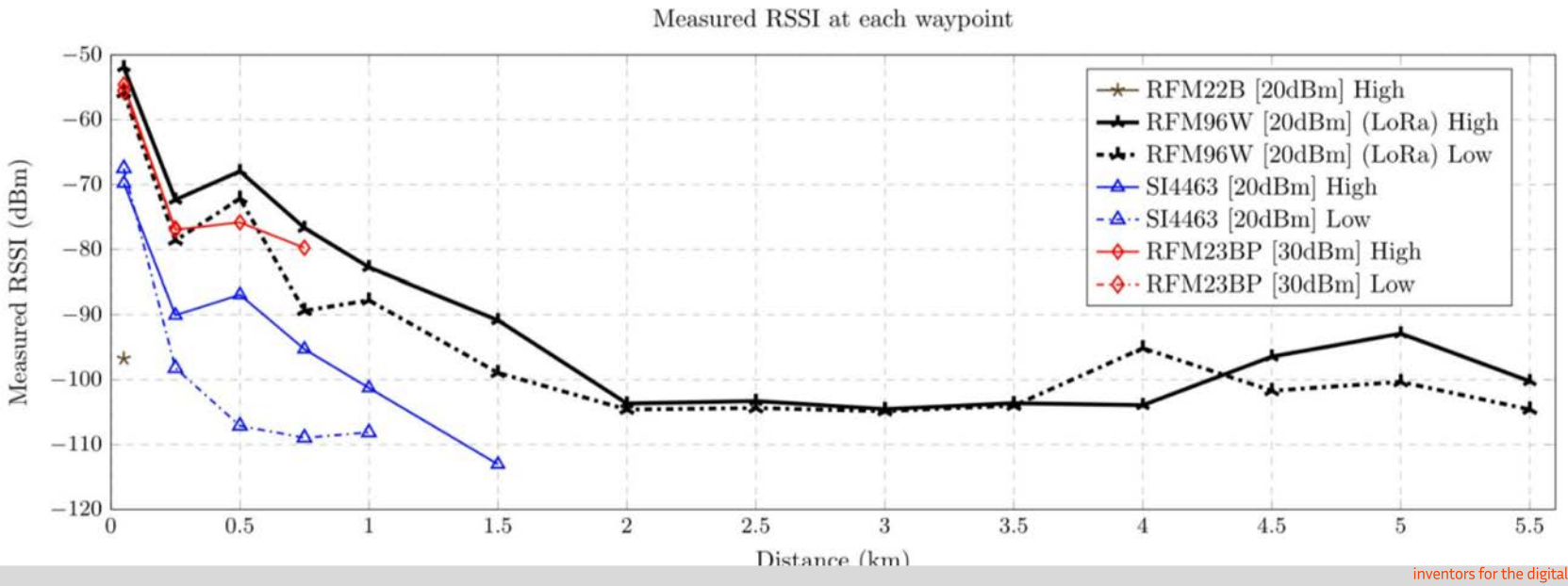
  → Results are not always as per the spec sheets ☹

In field tests



In field tests



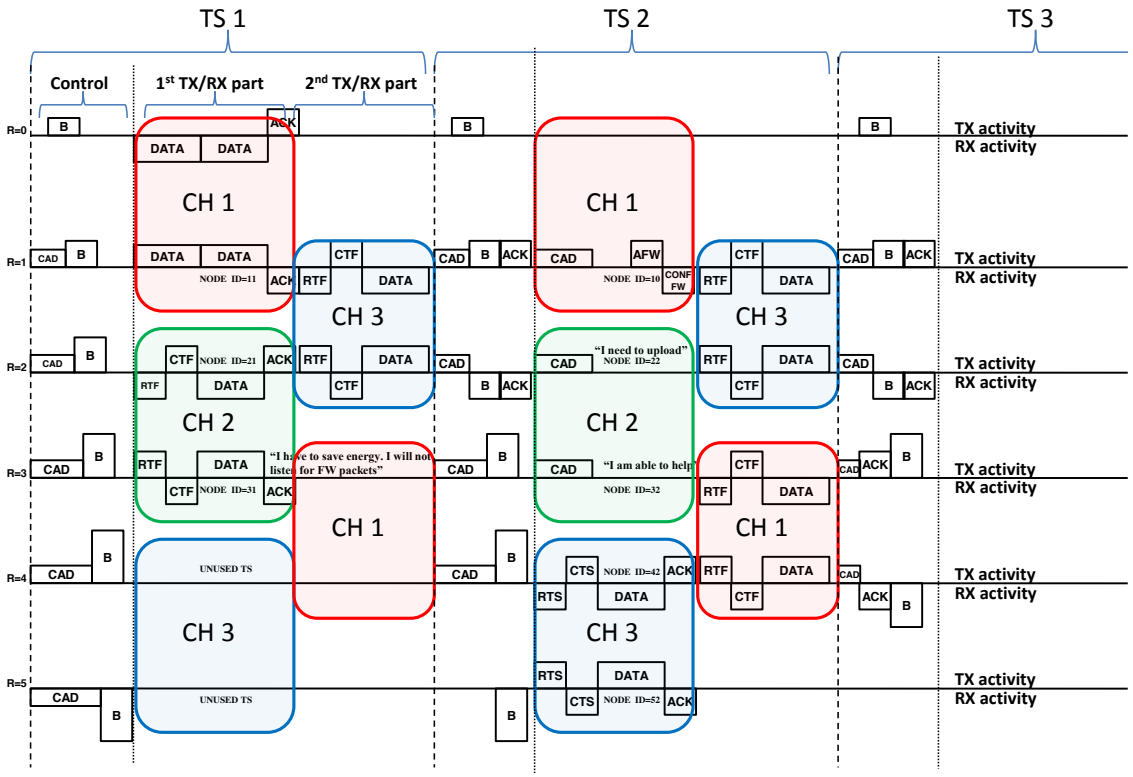


In field tests

Performance evaluation for different devices

Device	SI4463	**RFM96W**	RFM22B	RFM23BP	E31-TTL
Tx Power [dBm]	+20	**+20**	+20	+30	+30
Sensitivity [dBm]	-120	**-148**	-121	-114	-126
Modulation	FSK	**LoRa**	FSK	FSK	FSK

MAC layer timing diagram



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Bayesian approach

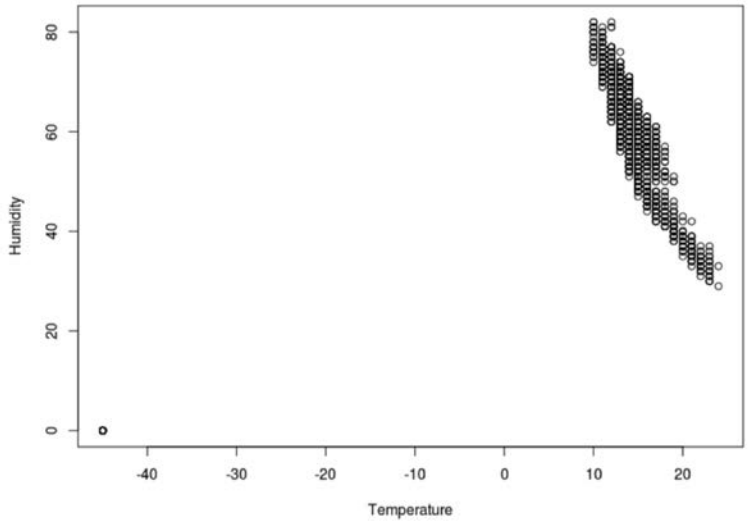

Figure 4: Relationship between humidity and temperature data.

Scenario	*#Transmitted data* [Byte]	EC [kJ]	MSE	ER
s_1	8408	1634.5152	-	-
s_2	4204	817.2576	0.62	0.295
s_3	4260	828.144	0.022	0.0066

Table I: Results obtained during eighteen hours of readings for different scenarios.



Experimentation vineyards where soil and environmental conditions are measured and studied




Rustenberg wines vineyard. Communications tests with LoRA modules

Planning and Summary

- Understanding and applying real hardware performance figures
- Verification in the vineyard
- BER tests have been implemented on four Arduino Mega boards. Final tests to be concluded
- Second series actual WSN PCB design in process
- More extended field trials in the new growing season
- A predictive model was created to estimate soil temperatures, given the weather data. With a modified linear regression method, the prediction error was 5.56%
- An improved neural network model currently provides an error of 4.8%
- This is promising and development of more advanced predictive algorithms to continue when more WSN data is available
- At this stage, no results have been found to indicate that the initial concept is not sound
- Design and test the full multi-techno adaptive communication protocol

Organisation, cross-visits and results

A French PhD in Stellenbosch October – December 2017

2 SA Masters students in Lille April – May 2018, July-Sept 2018

(One should be graduating end 2018)

Very promising sensor development work started by Belgian exchange student during last 6 months. To be continued by new student.

A new PhD student co-funded by Sencrop starting Sept. 17th

A special issue co-edited by R. Wolhuter and N. Mitton ate open access Future Internet revue **"WSN and IoT in Smart Agriculture"**

http://www.mdpi.com/journal/futureinternet/special_issues/wsn_iot

	year1	year2	year3	year4
PhD Thesis	1	2	NA	NA
Journal			NA	NA
Conference proceedings	4	1+ 2	NA	NA
General audience papers		1	NA	NA

Numbers in blue state for the paper under submission.

SWOT

Strengths	weaknesses
Multidisciplinray teams Real use case Access to experimental vineyards Support from the SA industry research body, Winetech	Lack of human resources
Opportunities	**Threats**
Support from PHC Campus France in addition to LIRIMA (to end in 2018) Support from Sencrop/FEDER/i-Site to come Transfer potential	Lacks of resources (human, traveling, etc)

Thank you – Merci – Dankie