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Sustainable Precision Agriculture from a Process Algebraic Perspective: a smart vineyard

Chiara Bodei, Pierpaolo Degano, Gian-Luigi Ferrari, and Letterio Galletta

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Calci , 7-8 Luglio 2016

Tecnologie e innovazione per una gestione sostenibile
dell'agricoltura,
dell'ambiente e della biodiversità

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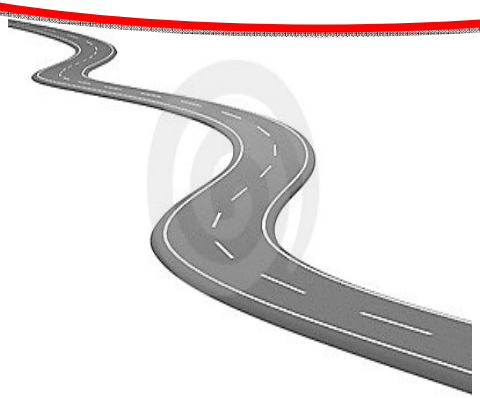
Smart ~~Precision~~

Farm ~~Agriculture~~

Precision Agriculture (PA)



- Observing
- Measuring
- Responding to

Variability in crops

- Climate
- Plant
- Soil …

w.r.t. locations

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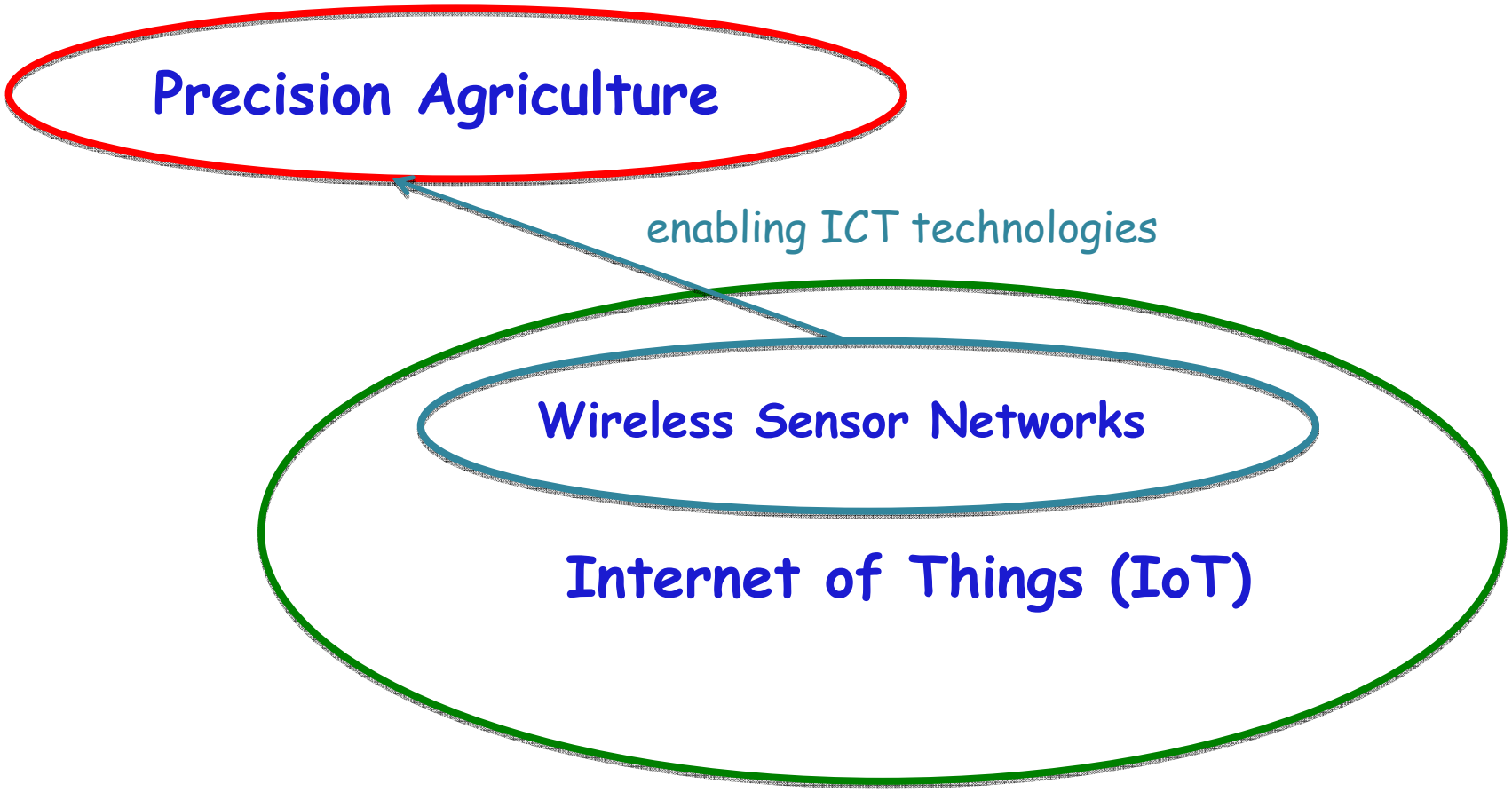
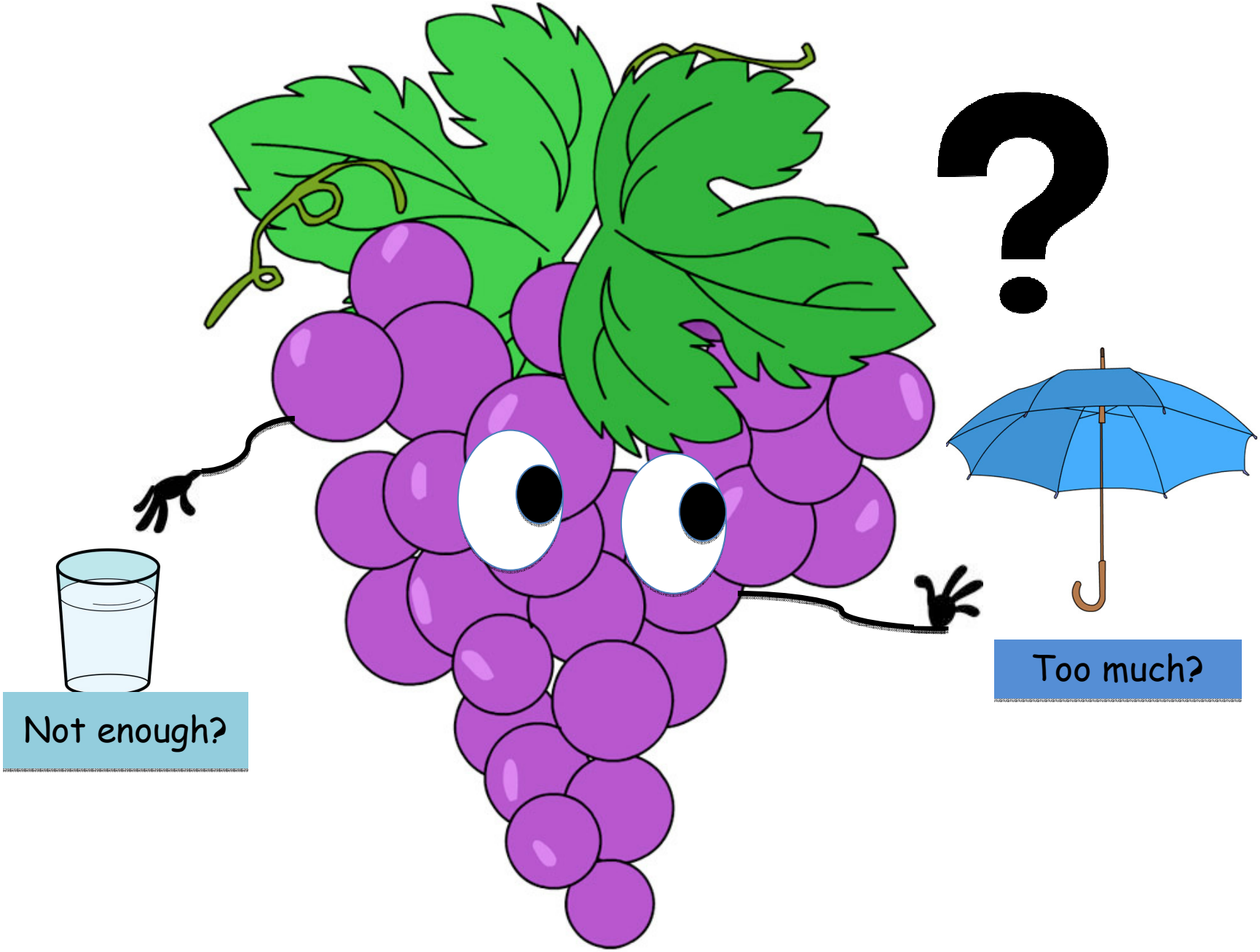


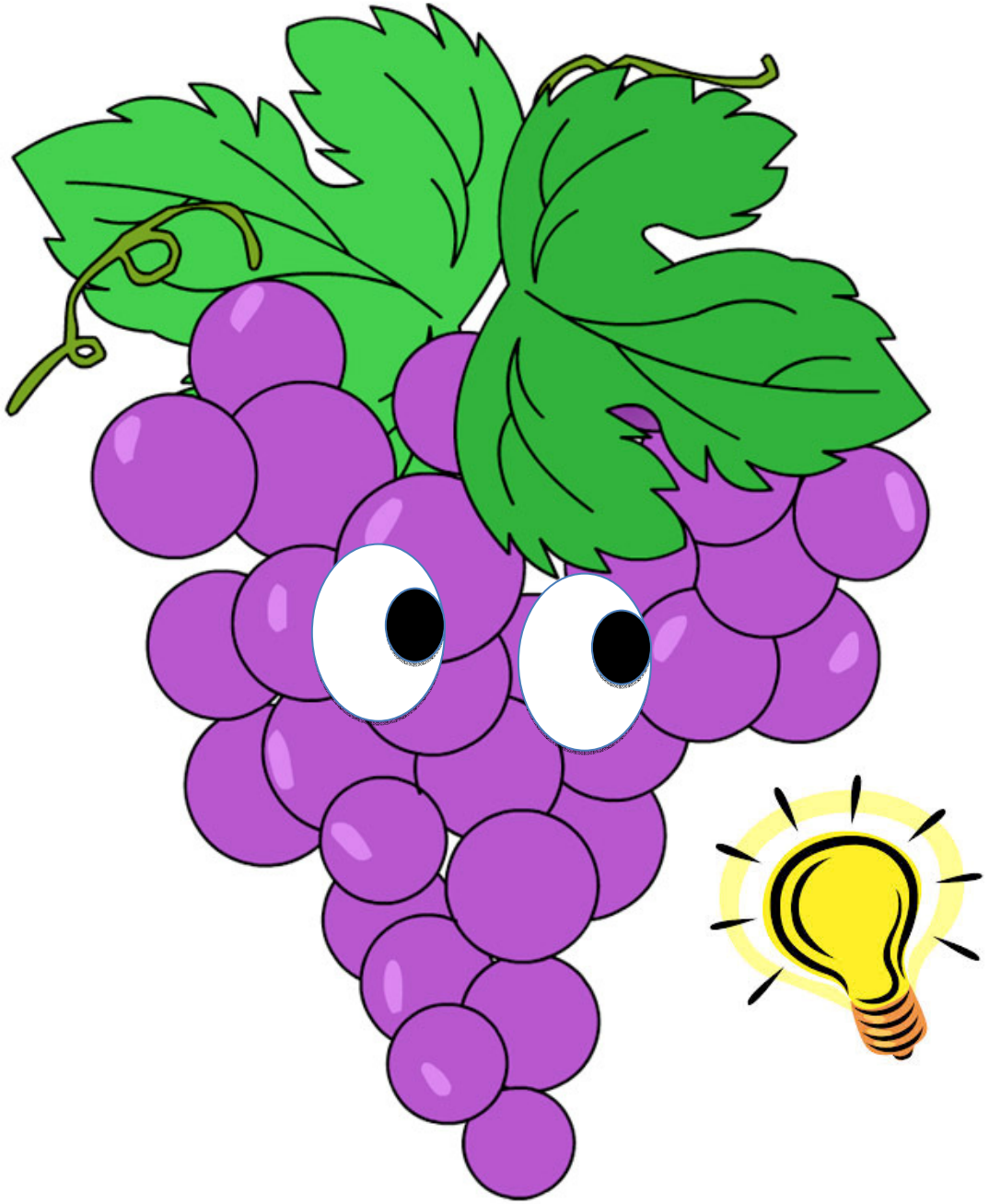
networks

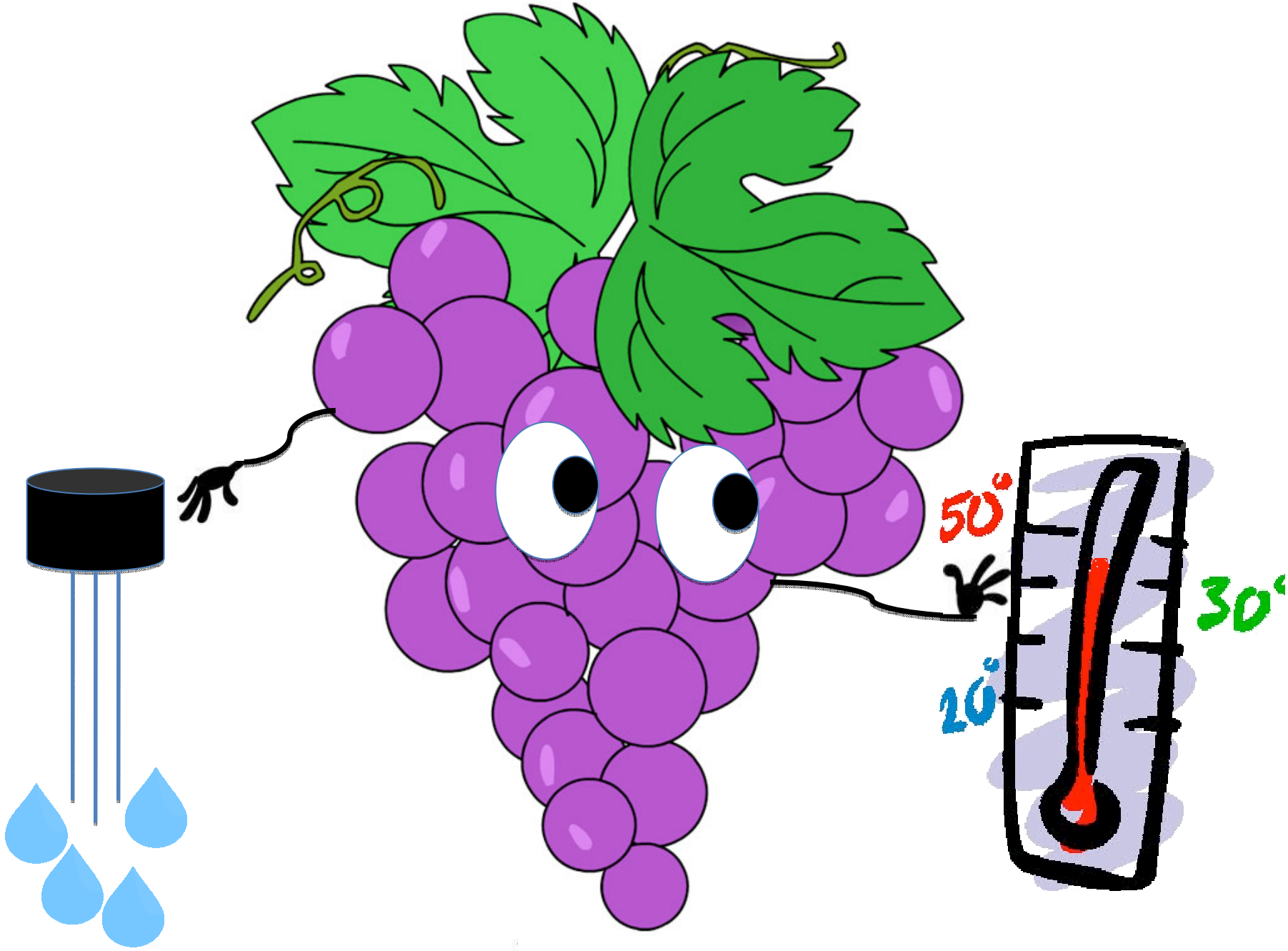
devices (i.e. the things)
observe the physical environment
+
processing nodes

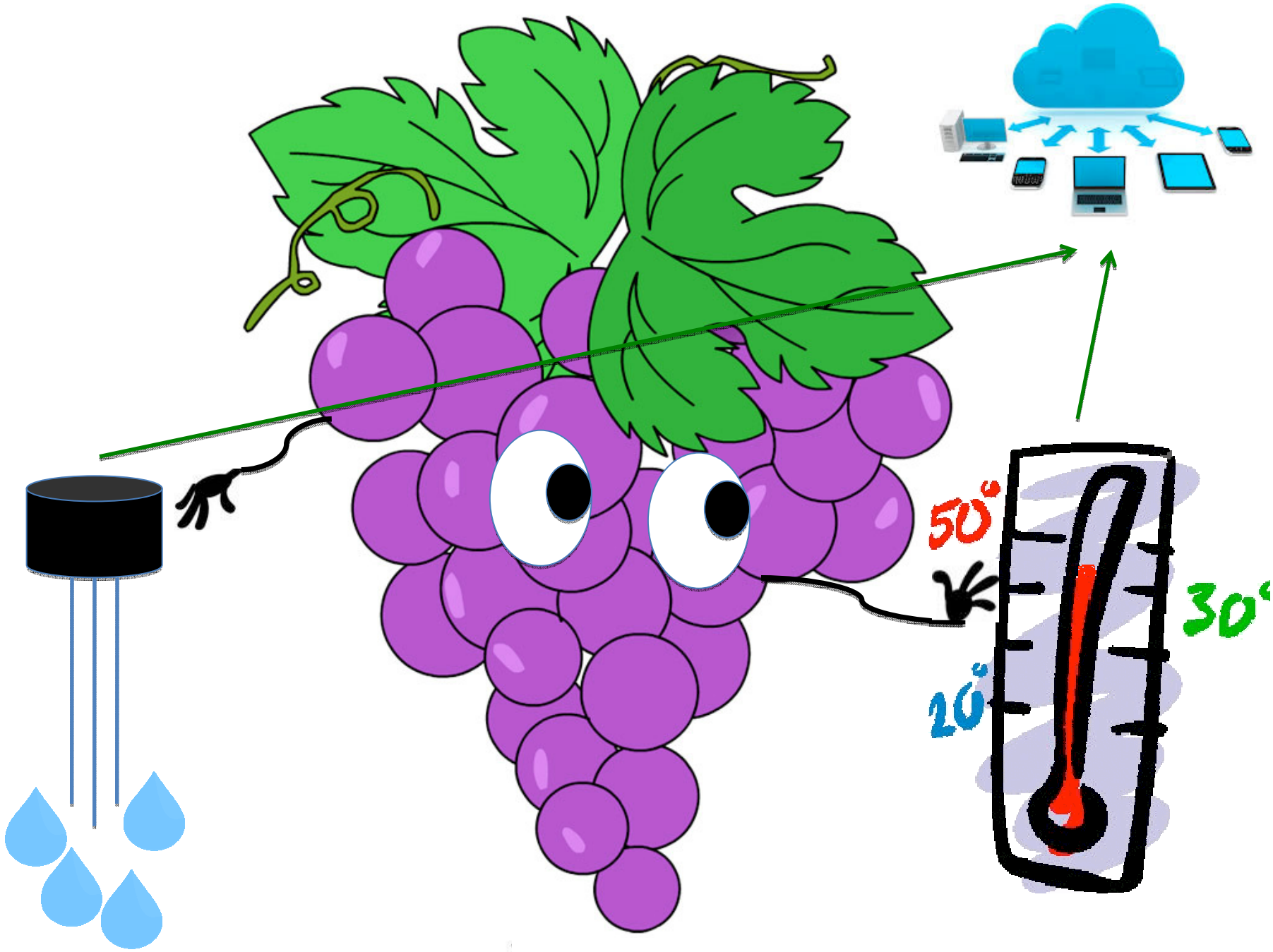
→ sensory capacity

→ talk to each other


?
Too much?
Not enough?




50°
30°
20°

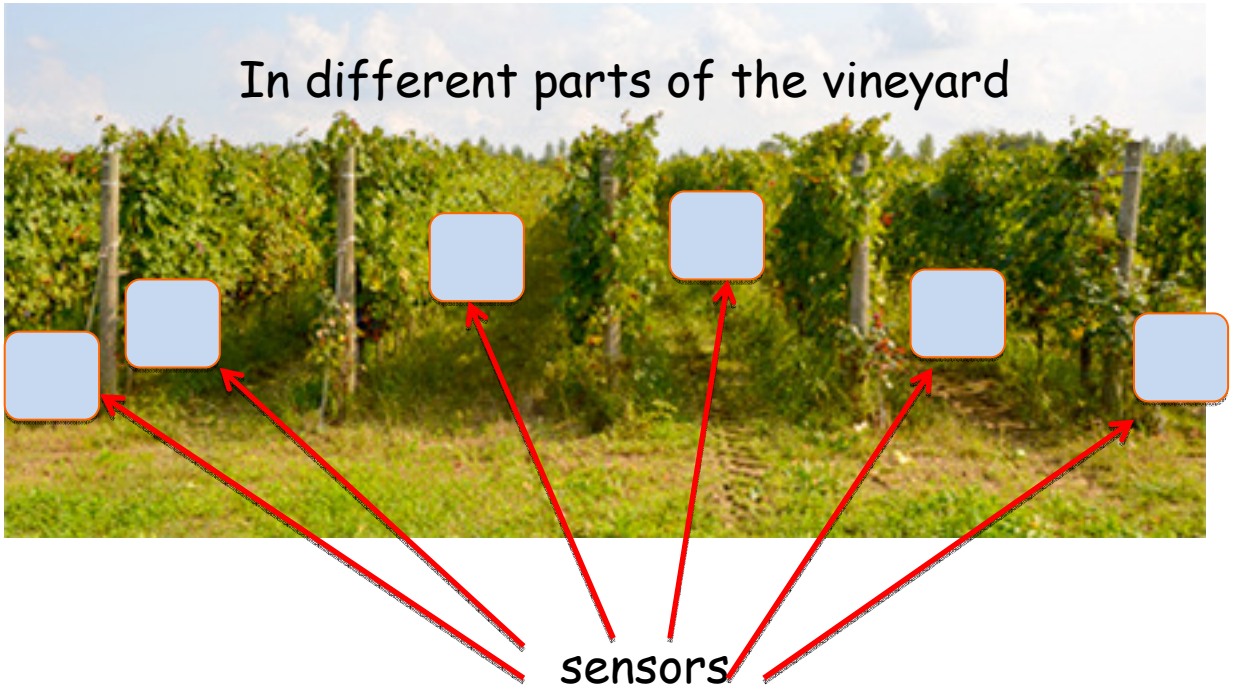

50°
30°
20°

Precision Agriculture

SENSORS TO COLLECT SUITABLE DATA

Precision Agriculture

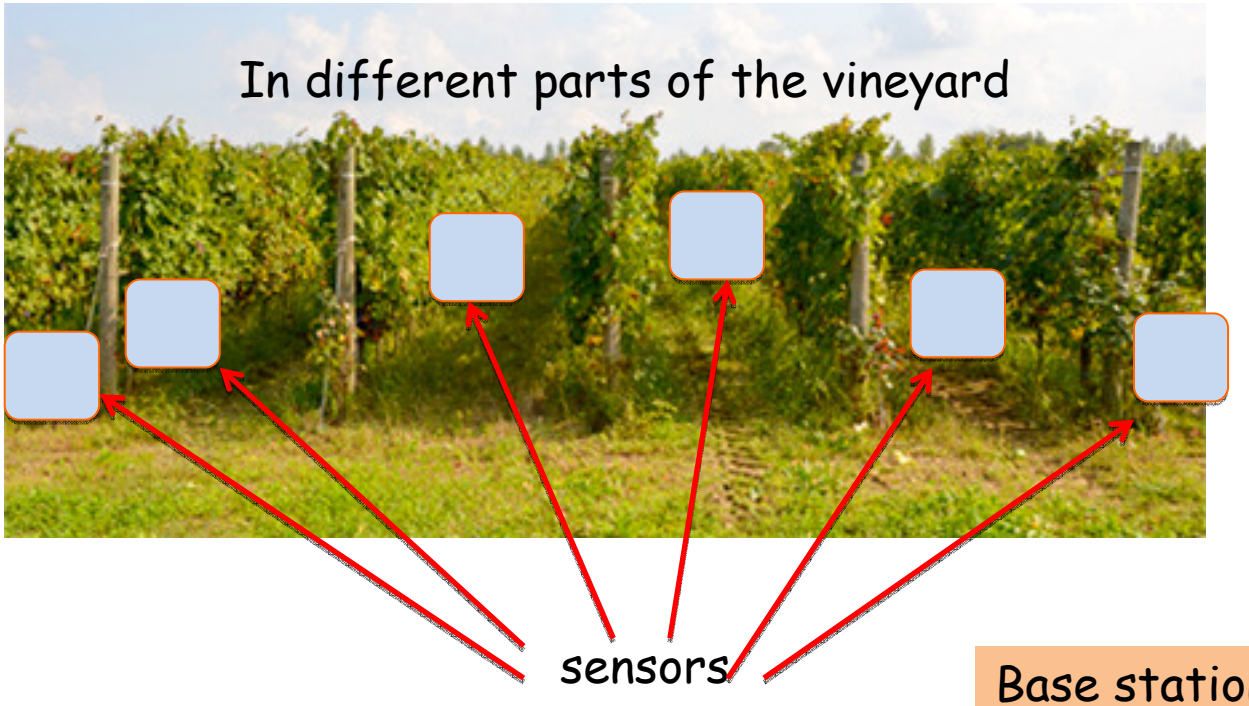
Real-time view of the vineyard



Low connectivity, limited battery,…
How to connect them to the Internet?

Precision Agriculture

Real-time view of the vineyard

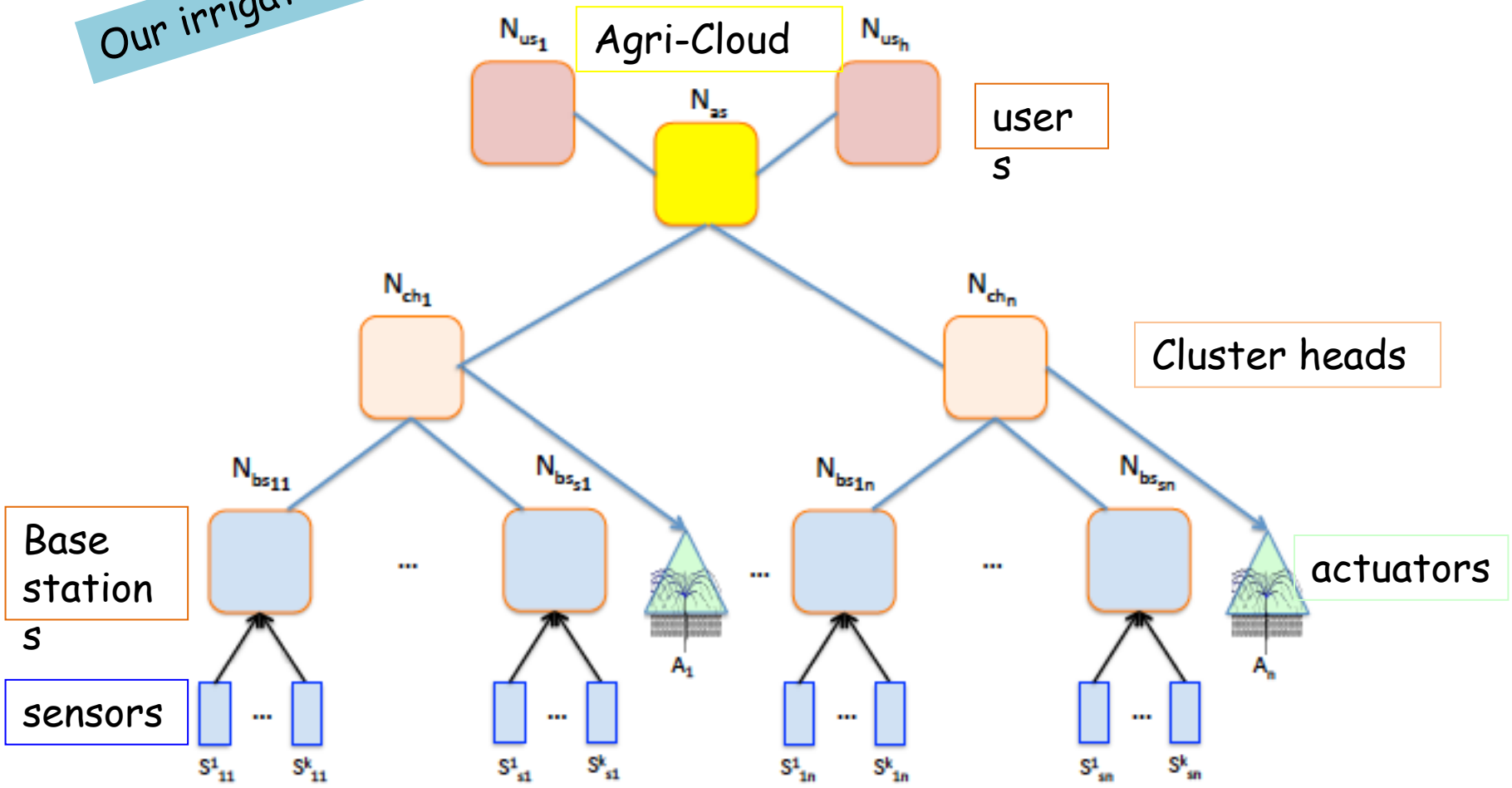


Low connectivity, limited battery,…
How to connect them to the Internet?

Base stations,
cluster heads:
- collect data
- send data remotely

(high-band connection)

Our irrigation control system



Sula Vineyard, Nashik (India)

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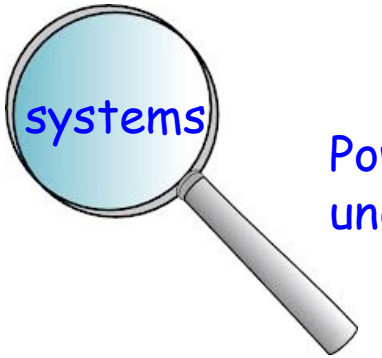
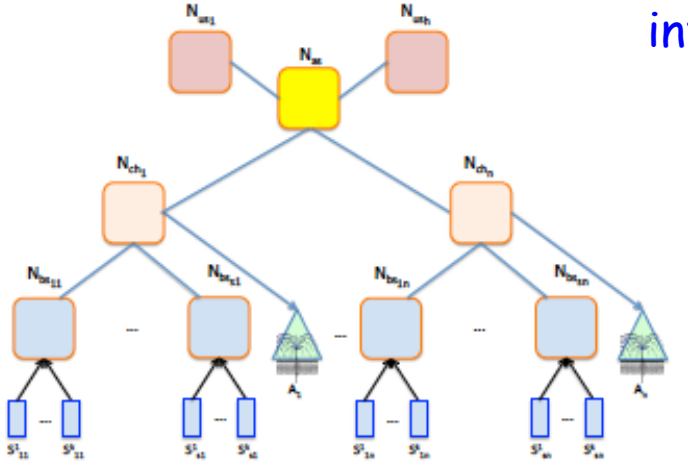


Powerful lens for describing and understanding systems

Process Algebra

very abstract programming language
with primitives for modelling
the **behaviour of a system**

composed by many independent and interacting components



Process Algebra

IoT-LySa

The server checks for each area if the water demand is below a certain threshold

$$N_{as} = \ell_{as} : [\Sigma_{as} \parallel P_{as,1} \parallel \cdots \parallel P_{as,n} \parallel P_{as,us_t}]$$

$$P_{as,1} = *[\ (1; w_{11}, \cdots, w_{1r}) \parallel (w_{11} \geq th_{11})\ ?$$

$$\langle 1, \text{StartIrrigation} \rangle : (w_{11} < th'_{11})\ ?$$

$$\langle 1, \text{StopIrrigation} \rangle]*$$

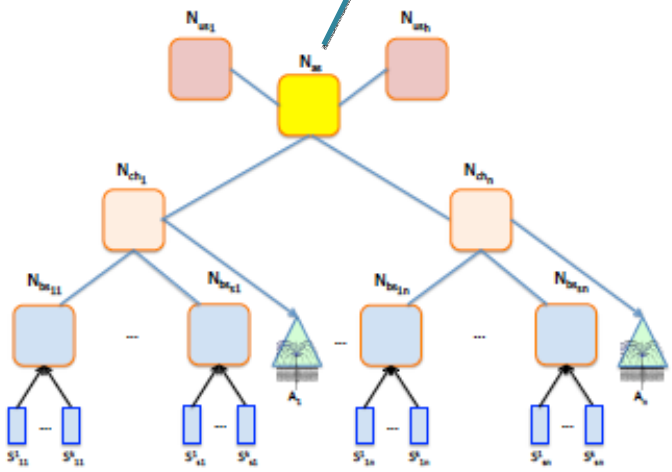
?

$$\vdots$$

$$P_{as,n} = *[\ (n; w_{n1}, \cdots, w_{nr}) \parallel (w_{n1} \geq th_{n1})\ ?$$

$$\langle n, \text{StartIrrigation} \rangle : (w_{n1} < th'_{n1})\ ?$$

$$\langle n, \text{StopIrrigation} \rangle]*$$



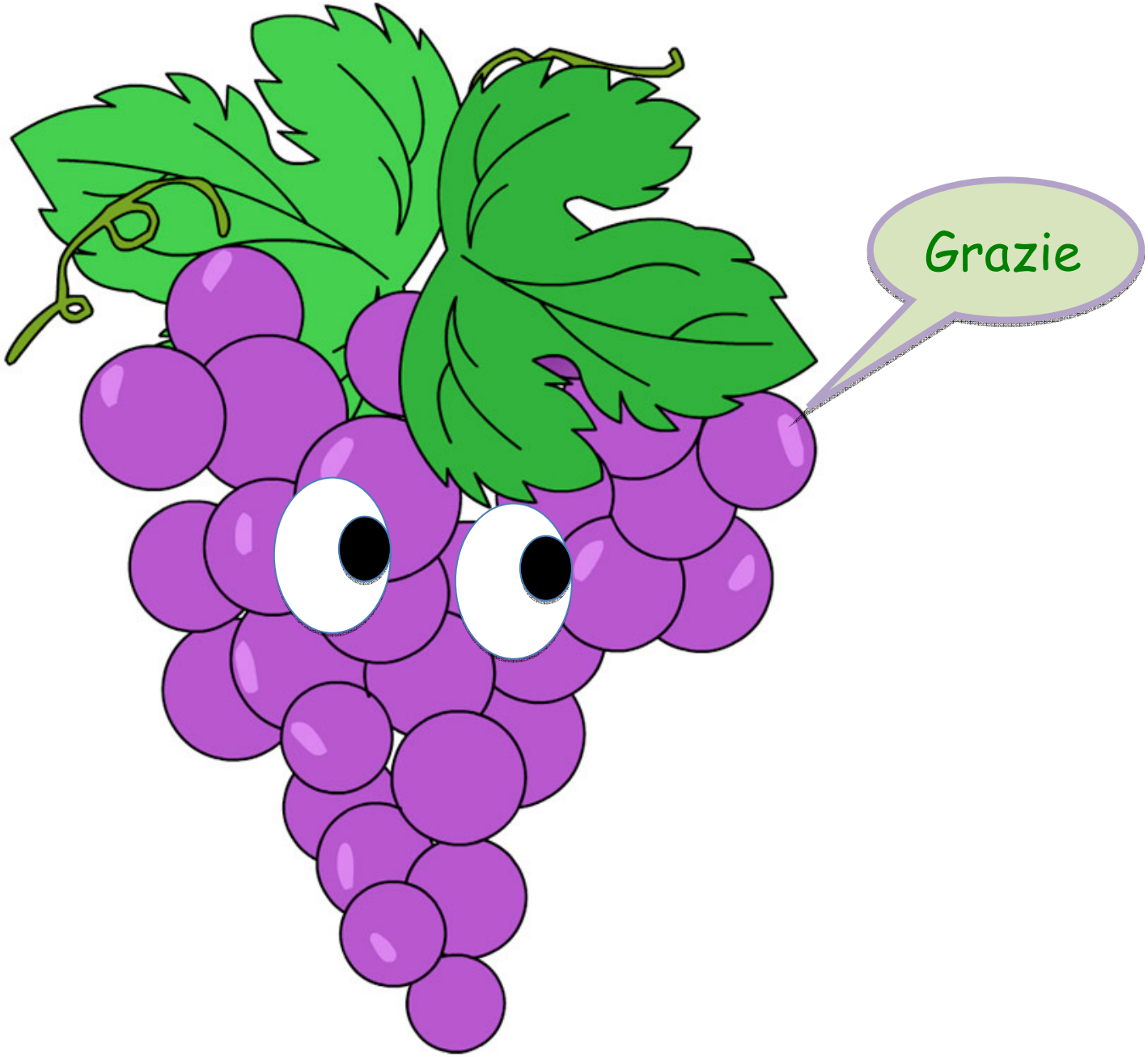
Support the design of networks for PA

Data-driven farming

Data analysis

- understand data-flows for decision-making
  - from where are to be gathered data
  - which kinds of aggregation functions are really necessary
- tune data collection depending on granularity of the observed areas, on frequency, on sampling,…
- checking properties of PA design

e.g.: what happens if a certain node is compromised or damaged?
Are the required overall functionalities still guaranteed?
Is our vineyard in danger?


Grazie