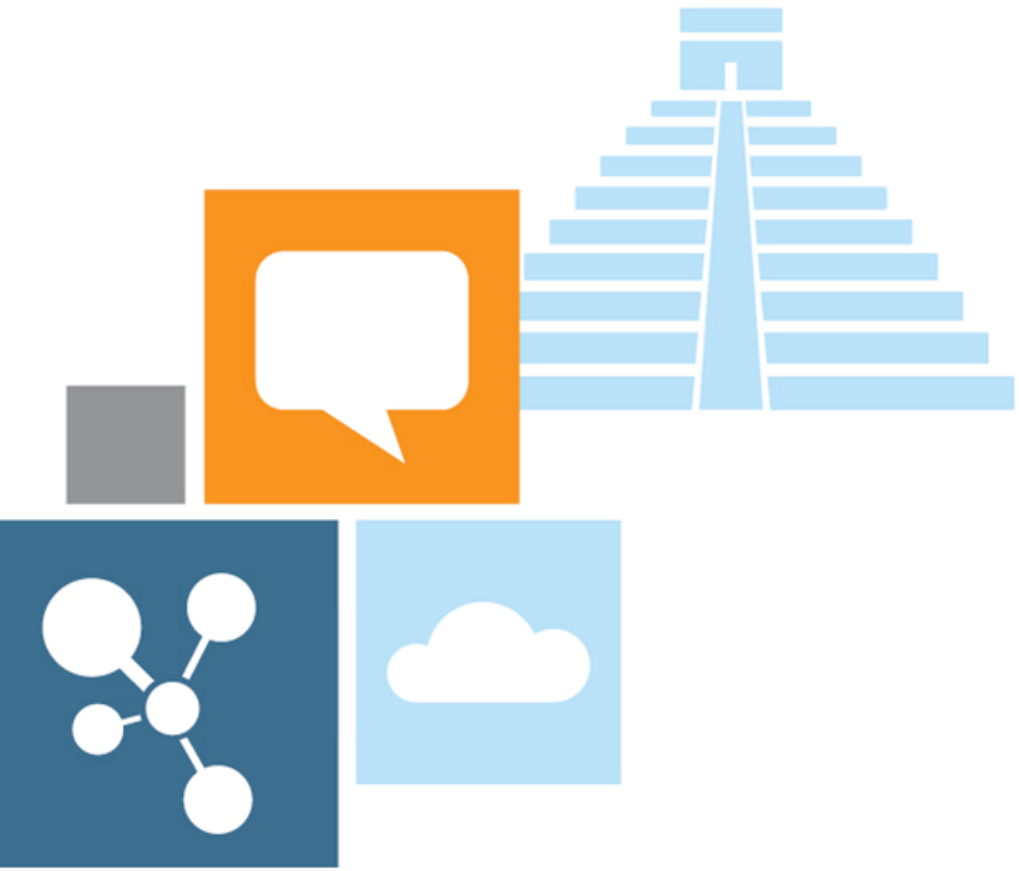
Microsoft



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# Using Sensor Networks to Classify Frogs Based on Their Calls

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Thursday, May 24, 2012

# Research Challenges

## Grand aligned challenges

Ubiquitous Computing [1]

Biological Diversity and Ecosystem Functioning [2]

## We need to understand the Earth's physical systems

Climates, geology, hydrology, …

## The rainforest is a key environment

Let's start with the Amazon forest

[1] Computing Research Association. **Grand Challenges in Computer Research**, 2002.

[2] National Academy of Sciences, **Grand Challenges in Environmental Sciences**, 2001.

# Key Problems

## An environment of extremes

Relative humidity: 70-90%

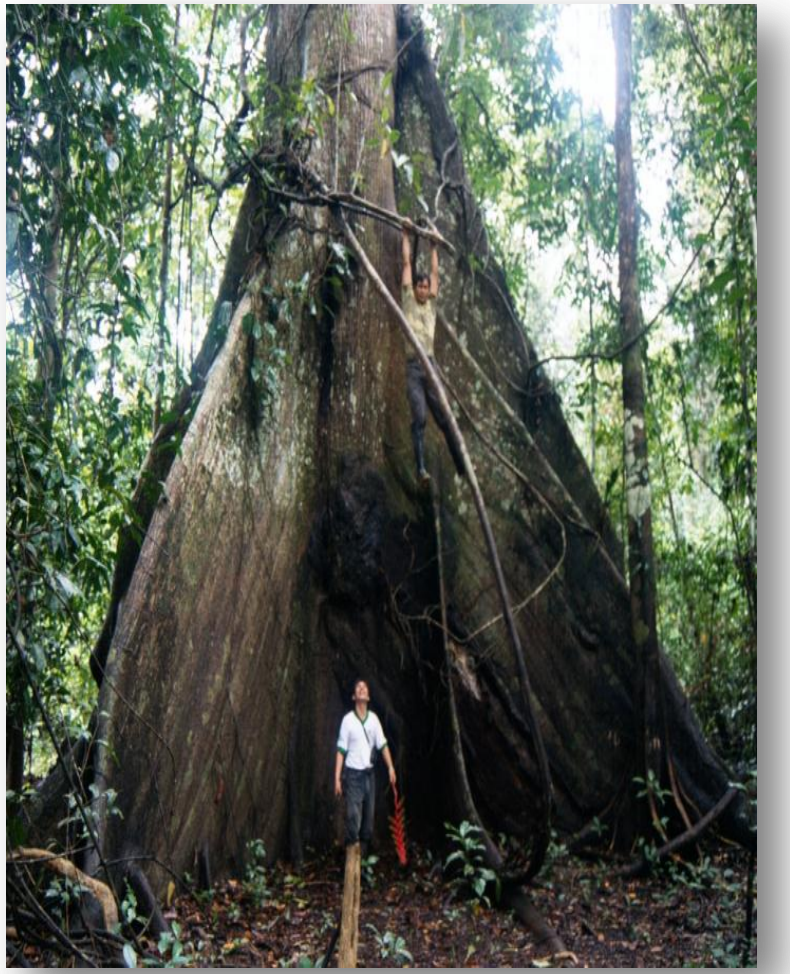
Temperature: 64-122 °F

Huge area, limited accessibility

## Additional challenges to WSNs

## Ecological issues

## Where should we start?



# The Anura Project

## ANURA: Sensor Networks for Classifying and Monitoring Frogs Based on Their Vocalizations as an Early Indicator for Ecological Stress in Rain Forests


## Financial Support

LACCIR - Microsoft
PRONEX - FAPEAM/CNPq (Brazil)

# Motivation

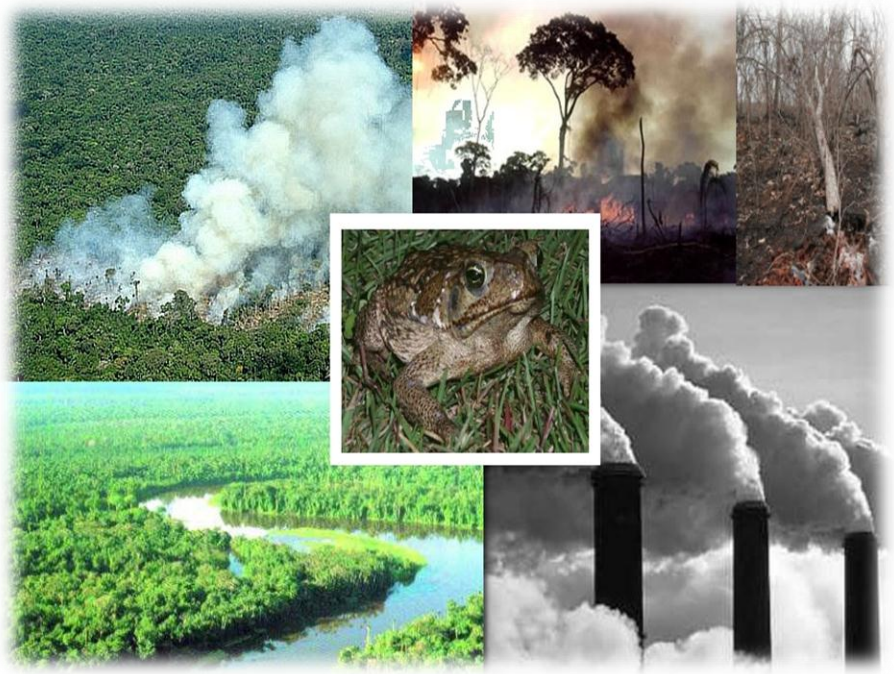
## Amphibians

Amphibians are very sensitive to changes (Carey et al., 2001)

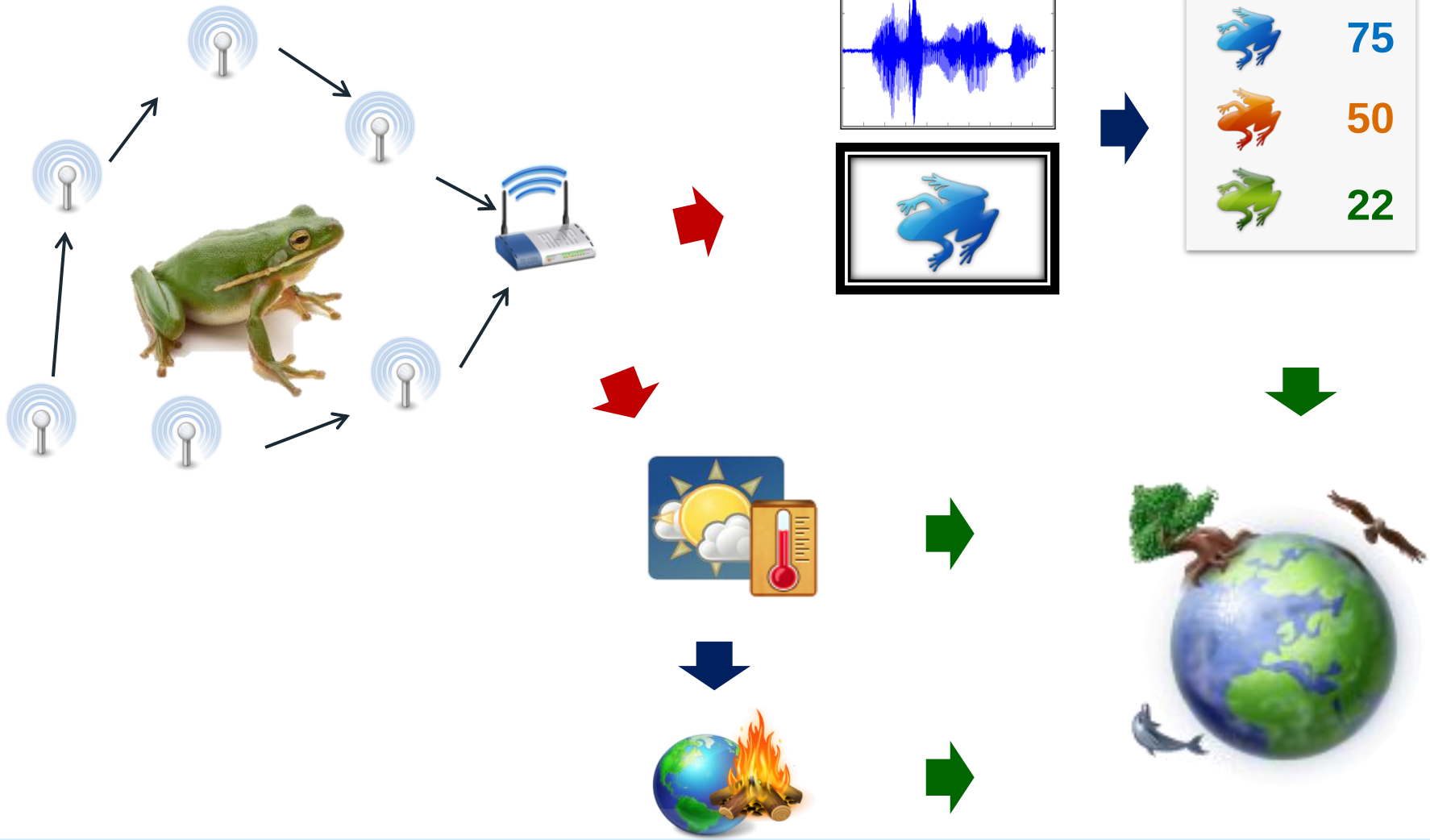
## Anurans (Frogs and Toads)

Closely related to the ecosystem (Alexander & Eischeid, 2001)

Fairly easy to be monitored

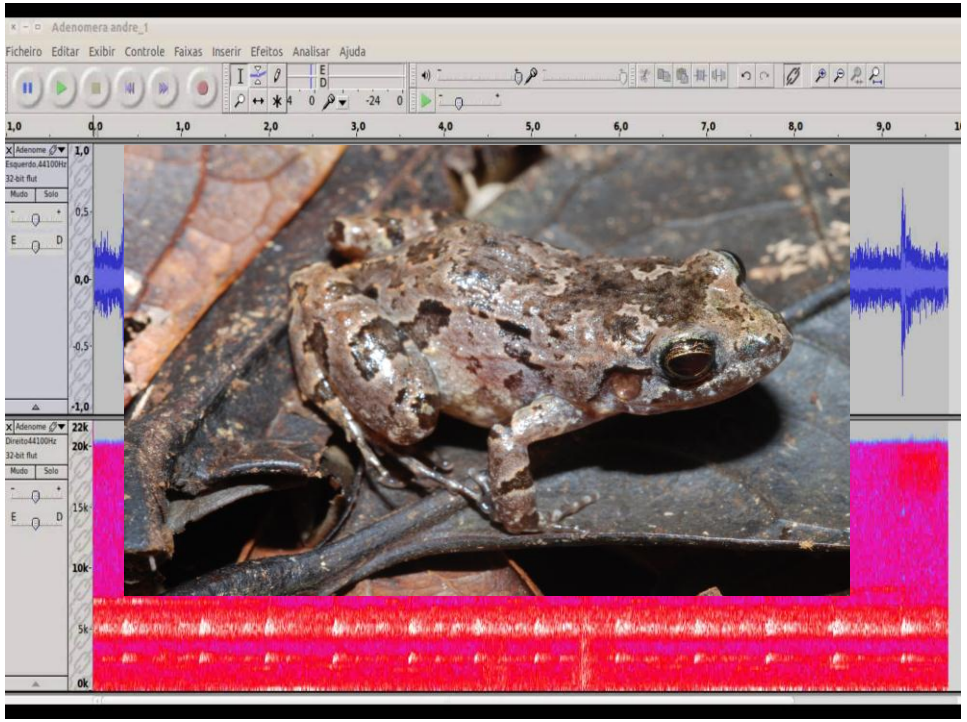


# Our Approach



# Data Gathering

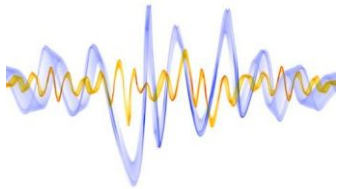
# Data Gathering




*Adenomera Andreae*

| Species | Individuals |
|---|---|
| Hylaedactylus | 8 |
| Rhinella granulosa | 3 |
| Adenomera andreae | 8 |
| Ameerega trivittata | 5 |
| Hyla minuta | 11 |
| Hypsiboas cinerascens | 2 |
| Leptodactylus fuscus | 4 |
| Osteocephalus oophagus | 4 |
| Scinax ruber | 4 |
| Total | 49 |

# Classifying the Anuran Calls



Preprocessing

Syllable segmentation

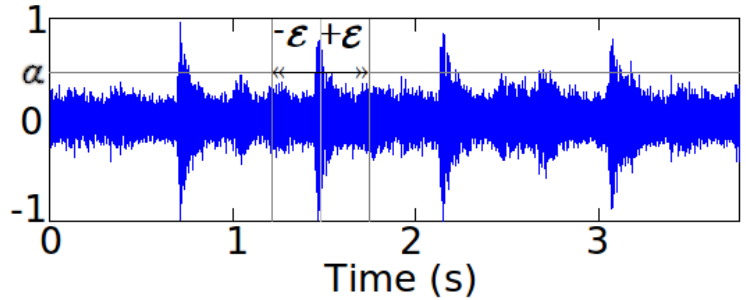
Preemphasis

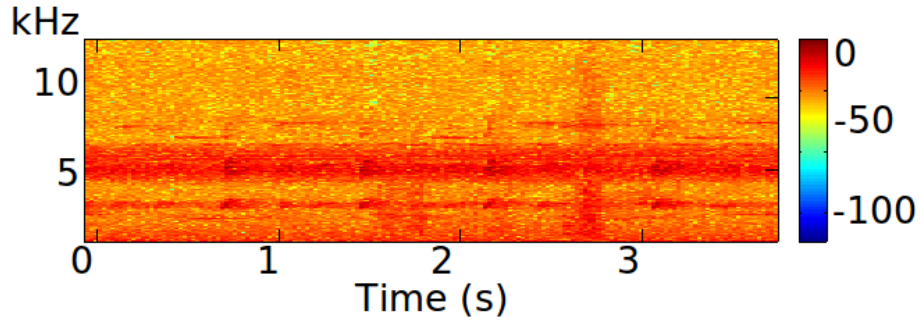
Feature Extraction

Classification

kNN

SVM



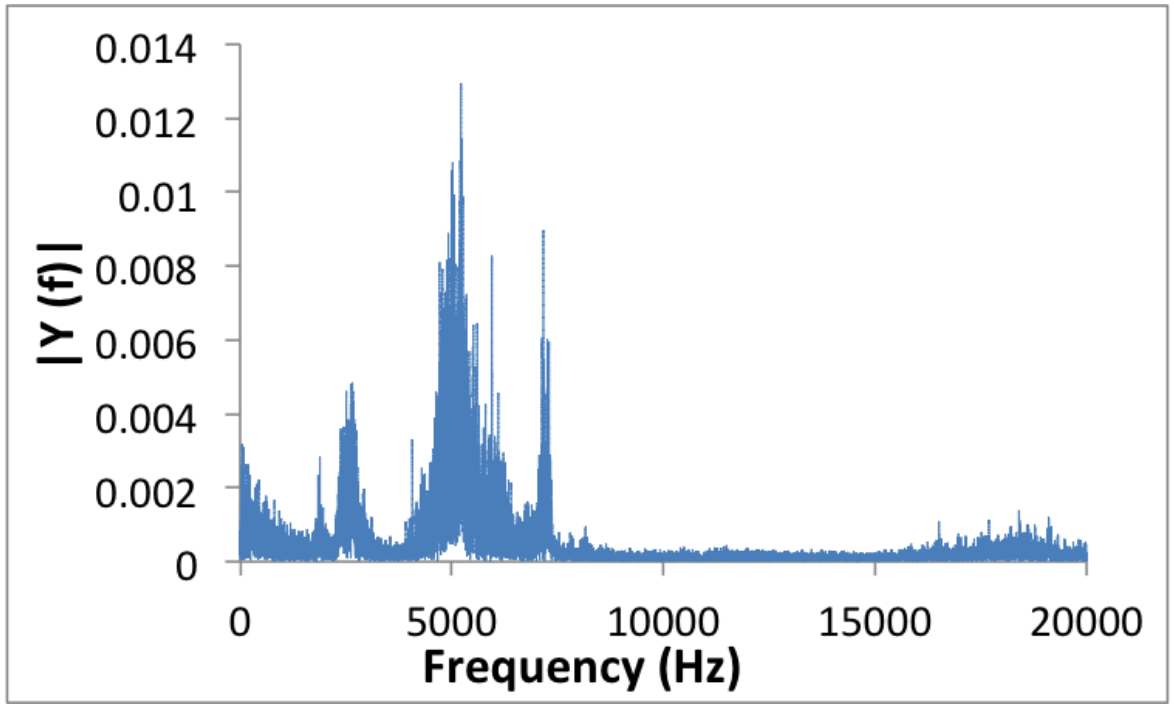
# Feature Extraction

**Time domain**

(R) Zero Crossing Rate
(S) Spectral Centroid
(B) Bandwidth

**Frequency domain**

MFCC
*Mel-Fourier Cepstral Coefficients*



# Best Results

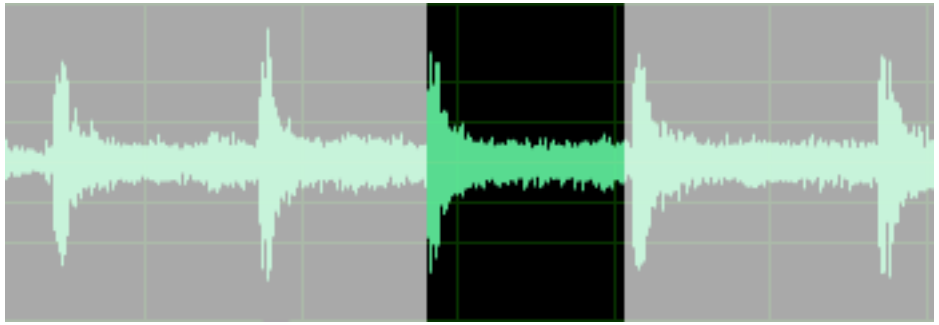
| Features Used for Classification | 5-NN | | | 10-NN | | |
|---|---|---|---|---|---|---|
| | α = 0.4 | α = 0.5 | α = 0.6 | α = 0.4 | α = 0.5 | α = 0.6 |
| MFCC (animals method) | 97.07% | 97.12% | 97.17% | 96.45% | 97.02% | 96.77% |
| RSB (anura method) | 87.98% | 89.83% | 91.39% | 87.93% | 90.21% | 91.06% |
| R & MFCC | 97.27% | 97.40% | 97.30% | 96.79% | 97.27% | 96.86% |
| S & MFCC | 98.10% | 98.14% | 98.22% | 97.59% | 97.77% | 97.86% |
| B & MFCC | 97.75% | 97.91% | 97.80% | 96.99% | 97.35% | 97.19% |
| RSB & MFCC | 98.41% | 98.53% | 98.43% | 97.89% | 97.95% | 97.89% |

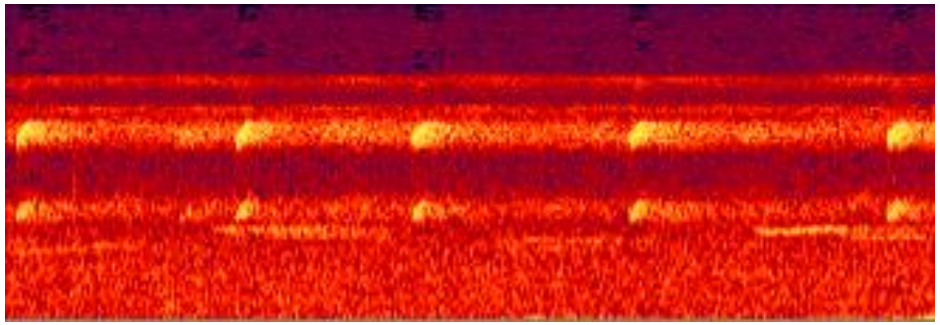
# Towards Efficient Data Gathering

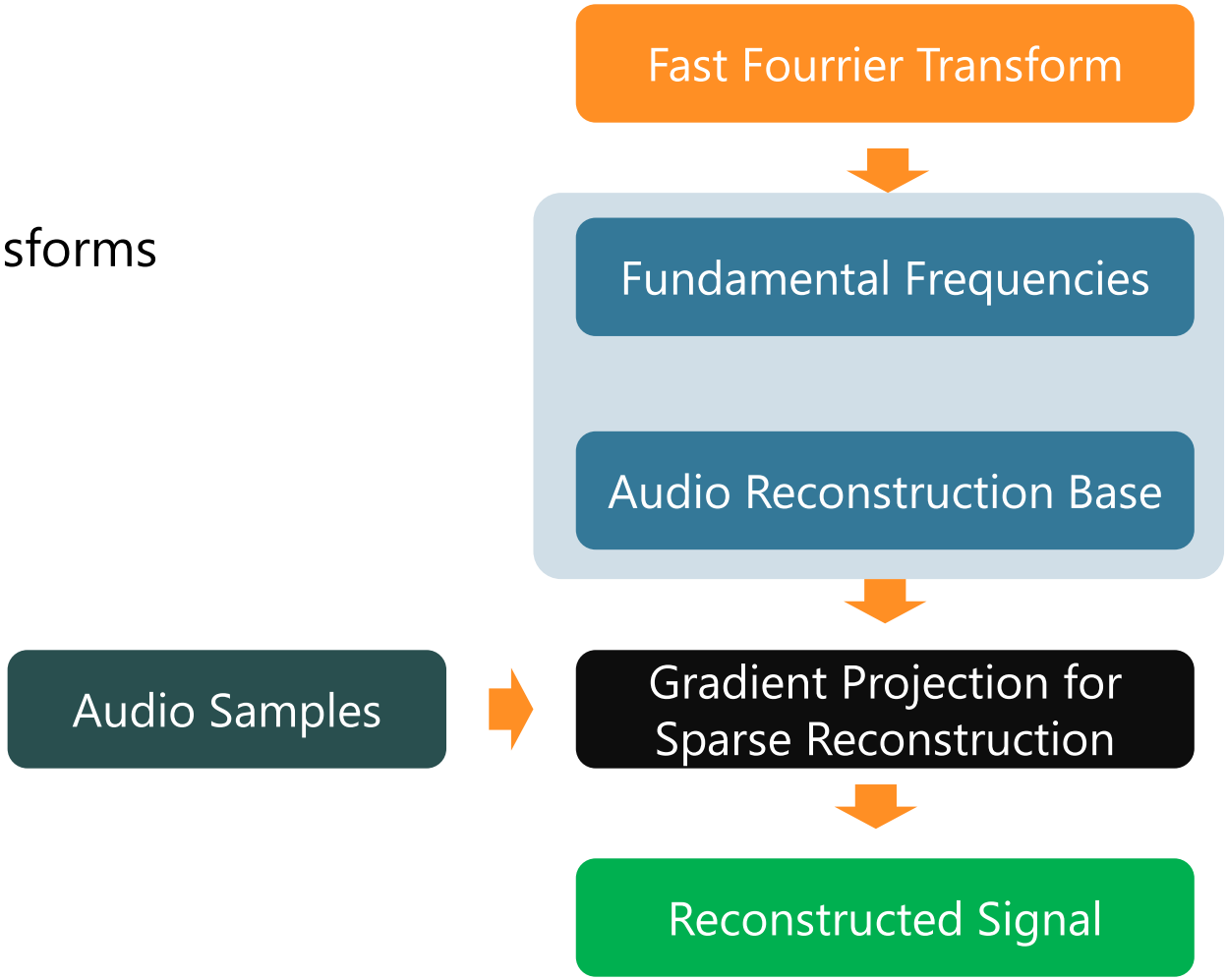
## Compressive Sensing

Reconstruct the signal based on samples

"Generalization" of Fourrier and Wavelet Transforms

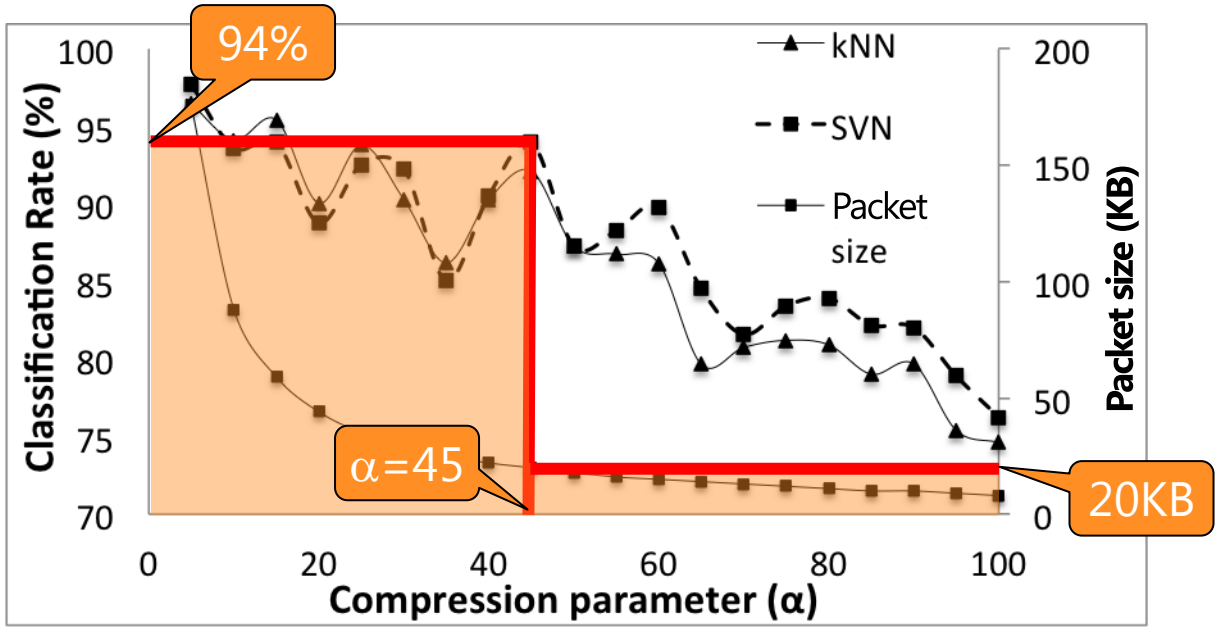


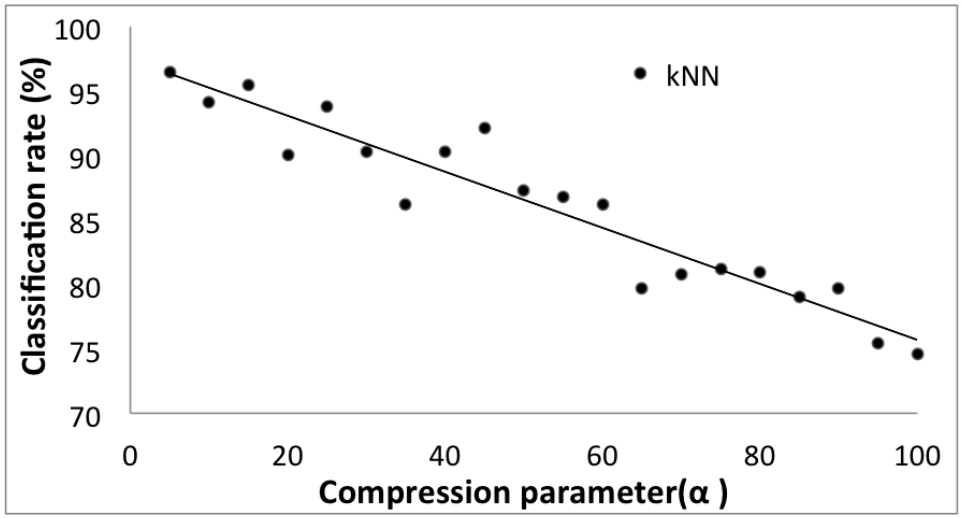


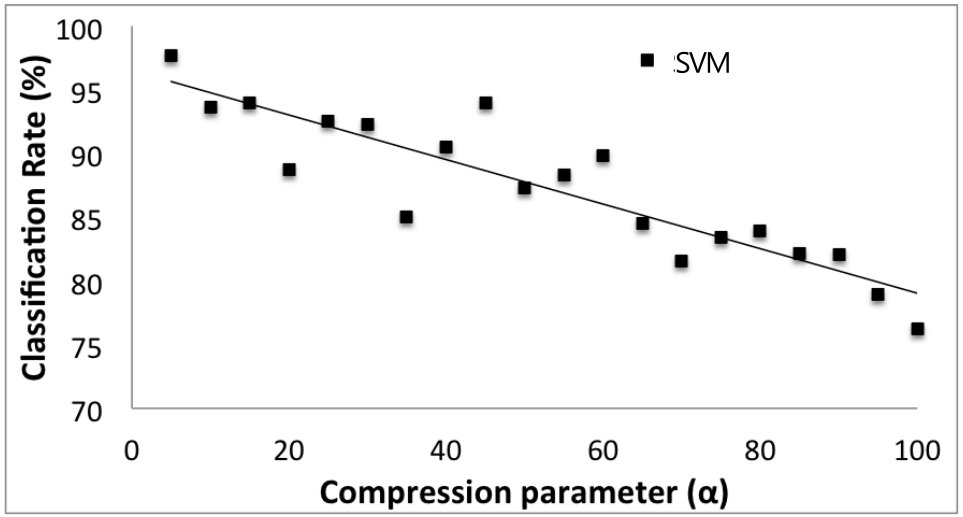


# Some Results

1.8 MB of sound



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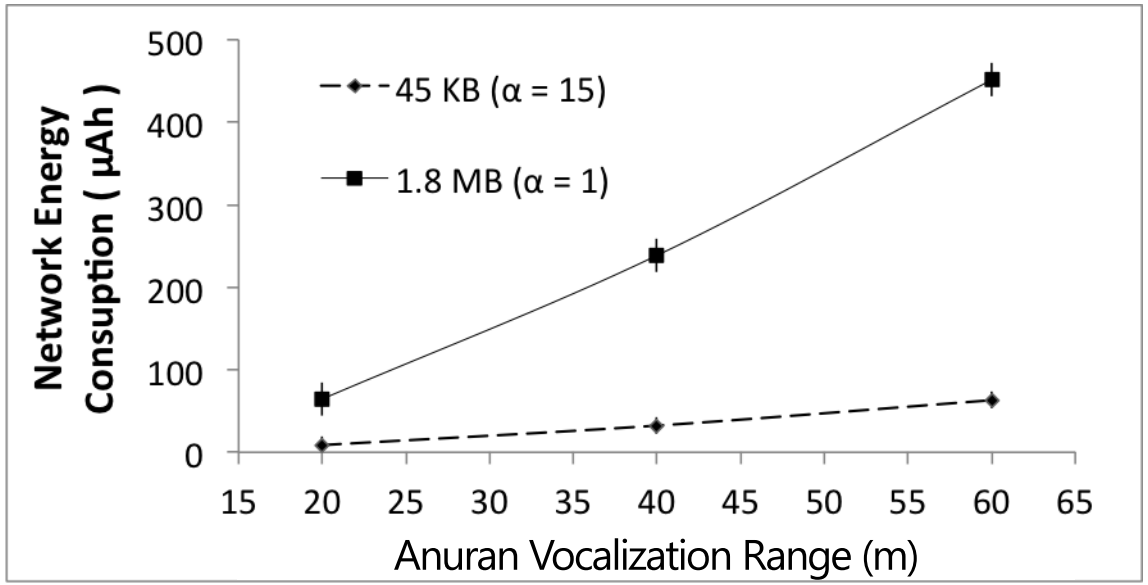
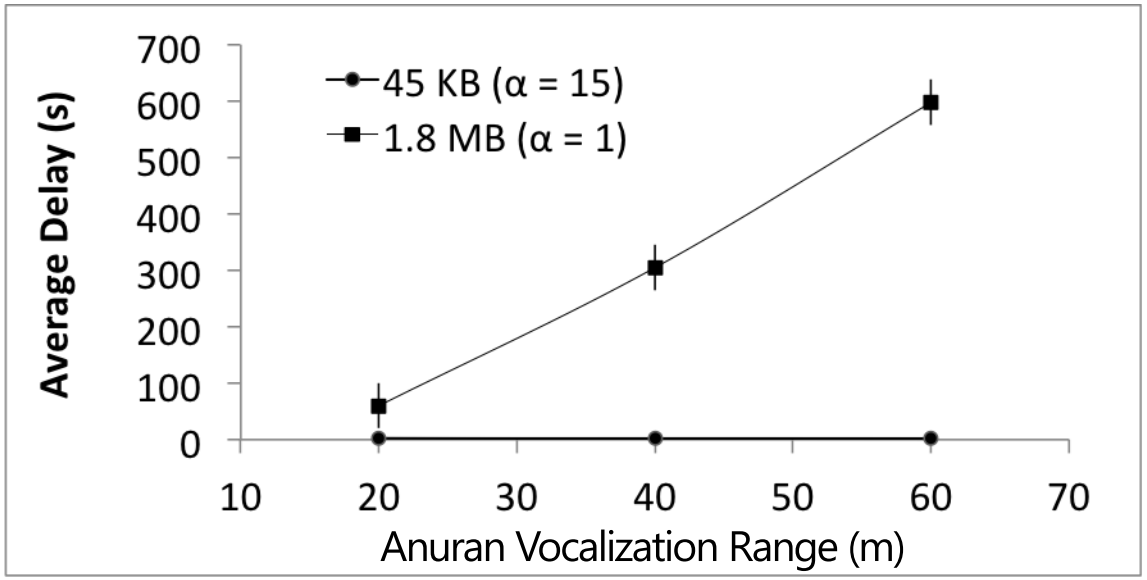


# Findind The Number of Species

## Data Clustering and Node Clustering

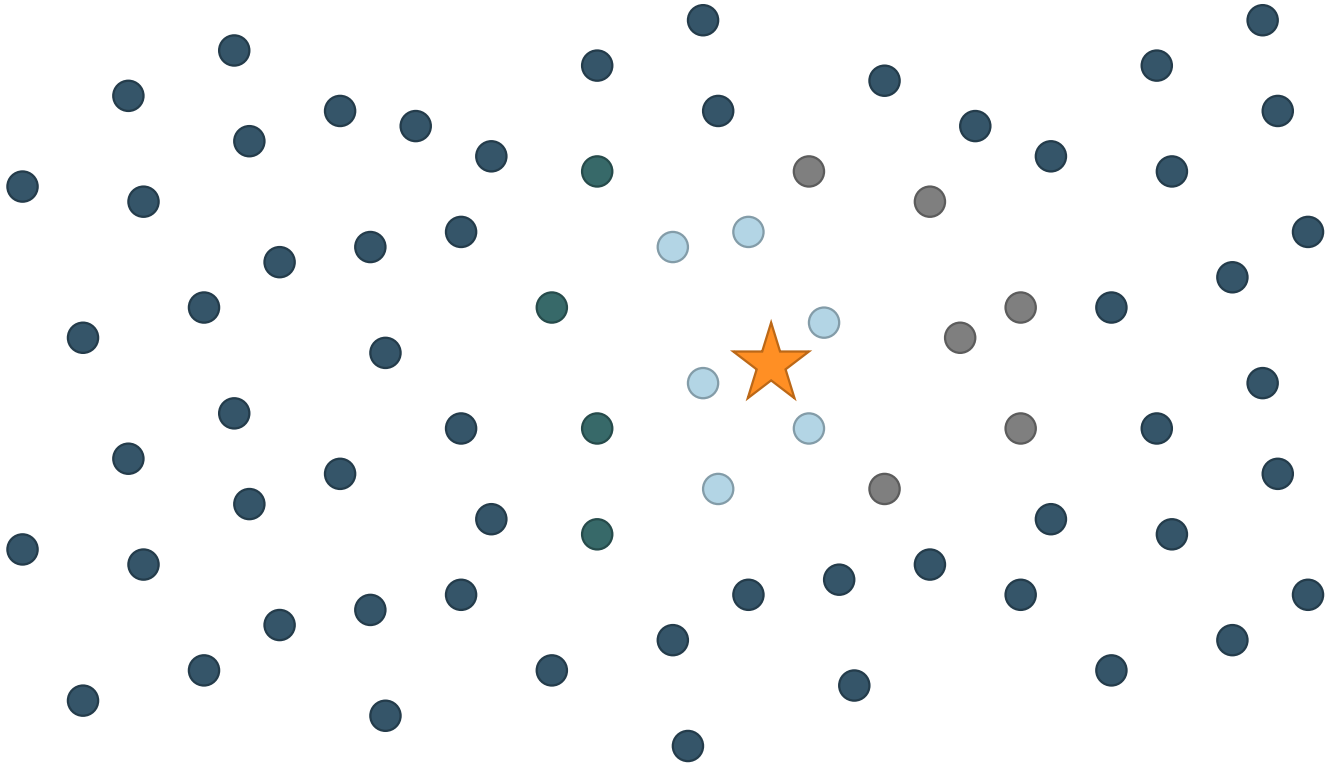
Improve Classification (data clustering)

Reduce energy consumption (node clustering)

## First Approach

K-Means for data clustering

# Our Approach



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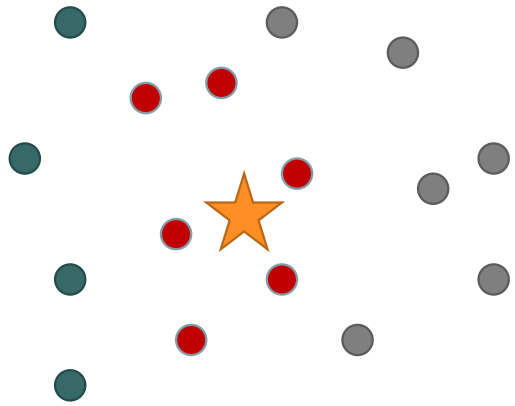

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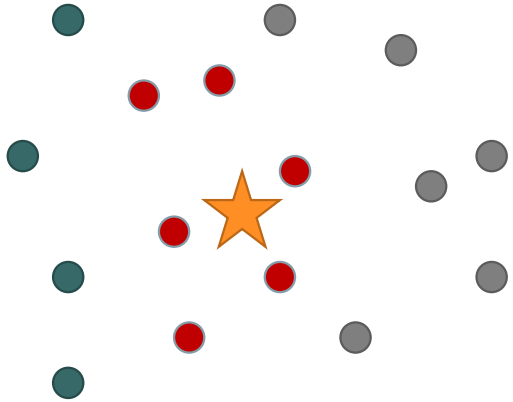

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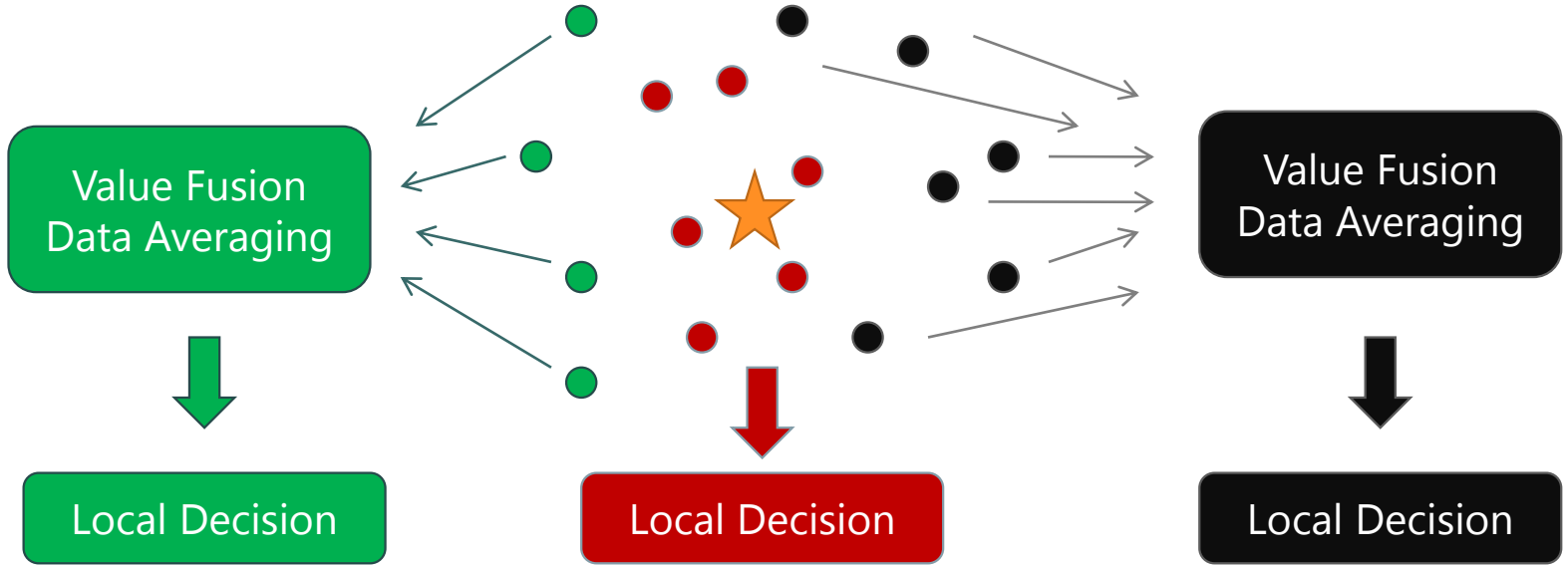

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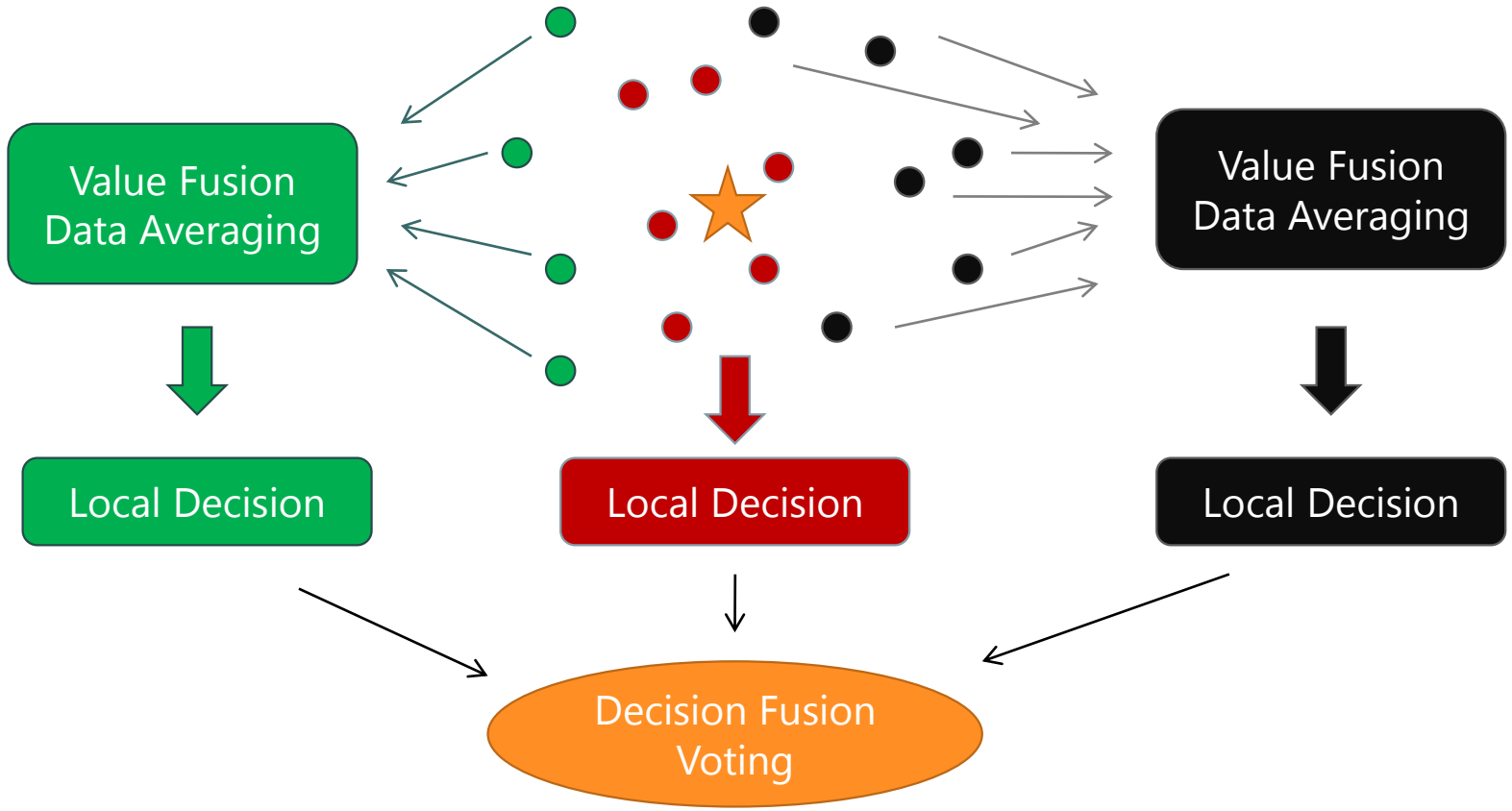


# What we discovered

## The best value for k

Positive correlation with the number of species

## Finding the best k

Tell us how many species are calling

# Conclusions

## Frog calls

Can be used for classifying species
Still cannot classify individuals

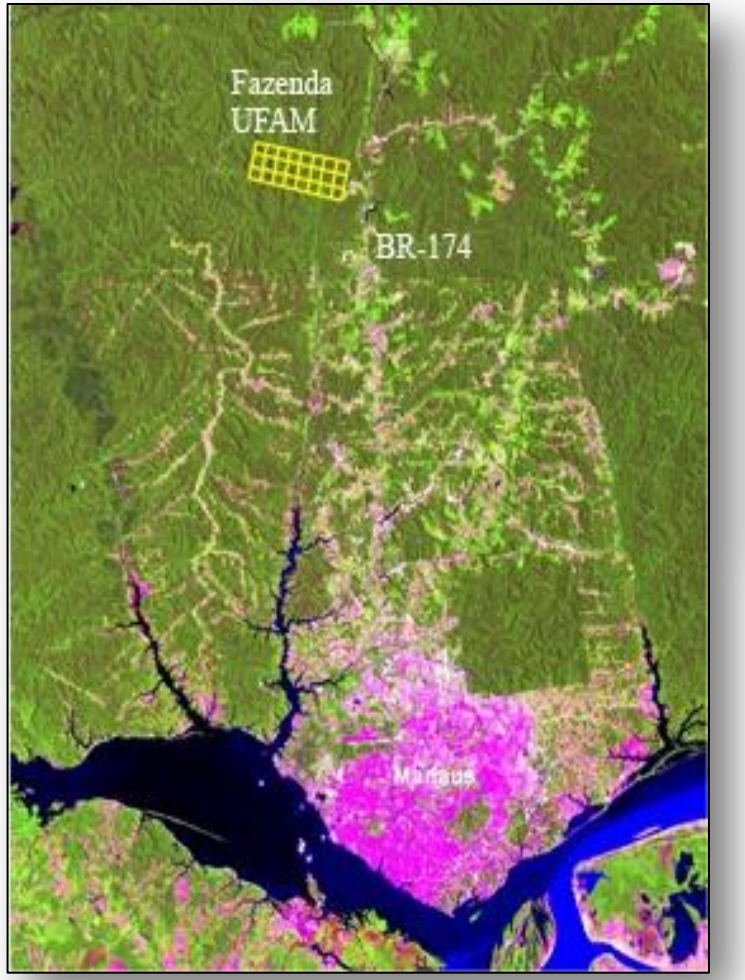
## Compressive Sensing

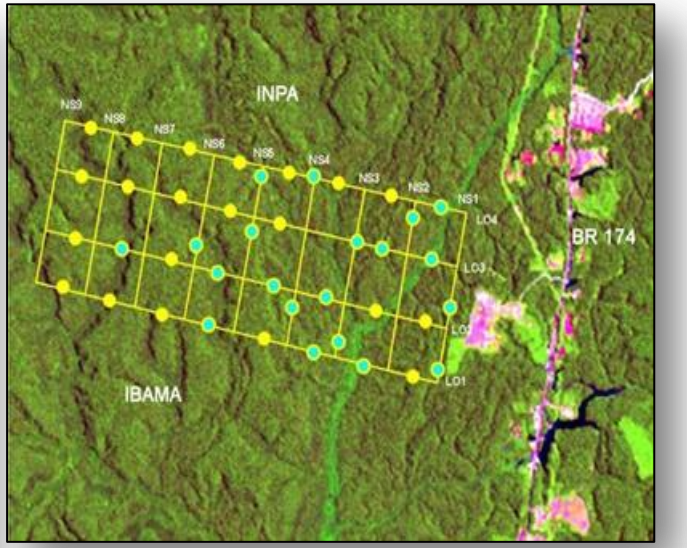
Efficient Data Gathering
Saving 88% of energy consumption (90% of data compression)
Classification success is close to 95%

## Data clustering

Give us a hint on the number of species
Even when we do not know the species

# Desired Deployment Site




# Acknowledgement

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