Energy efficient decision support system in ecology with novel classification algorithm

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Presented by:

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Outline

- Expert system for ecological management of water
- Energy Efficient protocols in wireless sensors – MAC level
- Lake Prespa energy efficient sensor network
- Algorithm for automatic generating rules in decision support system
- Model trees and rules obtain with the algorithm
- Decision Support System for Lake Prespa
- Conclusion

Expert system for ecological management of water

- Communication in wireless sensor networks can, like most network communication, can be divided into several layers. One of those is the Medium Access Control (MAC) layer.

- While traditional MAC protocols are designed to maximize packet throughput, minimize latency and provide fairness, protocol design for wireless sensor networks focuses on minimizing energy consumption.

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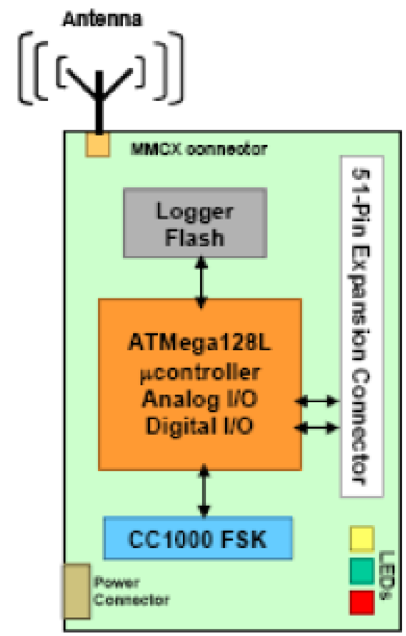
- The recent research based on MAC protocol layers, [6] introduce a novel system to handle load variations in time and location T-MAC introduces an adaptive duty cycle in a novel way: by dynamically ending the active part of it.



Expert system for ecological management of water

- The experiments conducted by [6] based on the implementation of the T-MAC protocol.

Msg/s	Transmit [mA]	Receive [mA]
0	0.138	0.138
1	0.400	0.246
10	1.516	0.890
Max	9.590	7.473

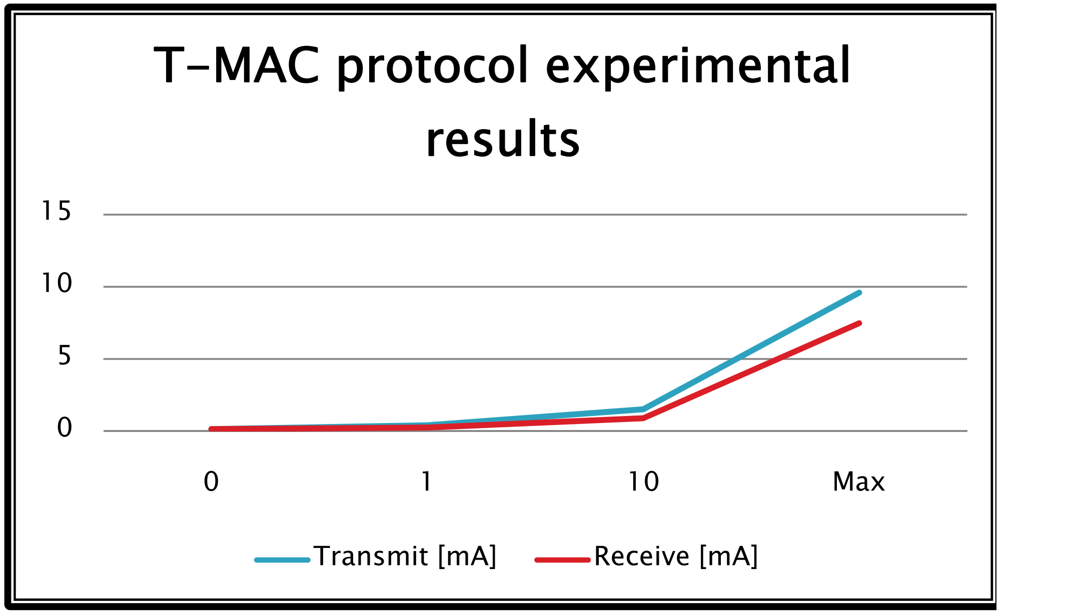


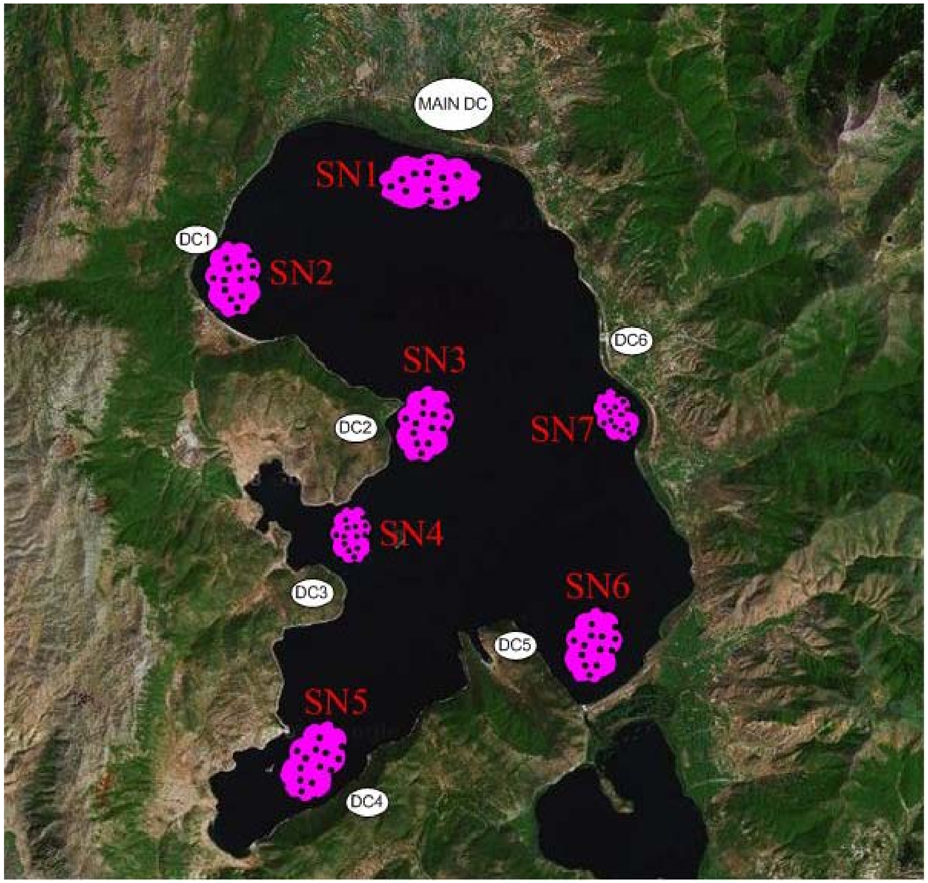
Table 1. shows the average electrical current during each experiment. We can see that transmitting nodes use significantly more energy than receiving nodes.

More importantly, we see that the idle average current (0.138 mA) is less than **<u>4%</u>** of the current of a non-energy saving protocol (which would be between 3.75 and 4 mA)

Lake Prespa energy efficient sensor network

- The presented algorithms previously should be implemented in the proposed sensor.

1. Those sensors can move from time to time, and will send measured parameters to the nearest Data Centre
2. As can be seen, there have only one Main Data Centre (MAIN DC in Fig.2), where the decision support system with a novel diatom classification algorithm is implemented and is connected (wireless with GSM/GPRS – Global System for Mobile Communications/ Generic Packet Radio Service) with other six Data Centres



Algorithm for automatic generating rules in decision support system

- The measured data processed by the decision support system is then analysed using a novel diatom classification algorithm.

- Every model tree than can be easily converted into the rule and presented to the decision makers and environmental engineers.
- The pattern tree method is composed by different similarity measures and fuzzy aggregation. One similarity metric is used in our research work, the RMSE metric.

$$RMSE(A;B) = \sqrt{\frac{\sum_{i=1}^{n}\left(\mu_A(x_i) - \mu_B(x_i)\right)^2}{n}}$$

$$Sim(A;B) = 1 - RMSE(A;B)$$

Note that the pattern tree induction follows the same principle if alternative fuzzy set similarity definitions such as **Jaccard** are used.

Fuzzyfication of the input dataset

- Fuzzy membership functions and their values.

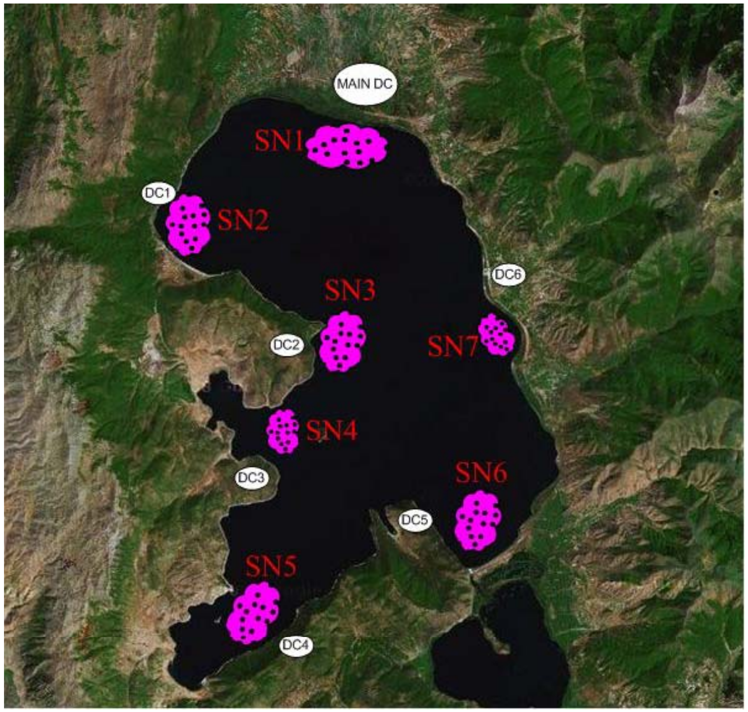
TOP 10 Diatoms	Low	Medium	High
APED	0-4.335	4.34-8.665	8.665-13
CJUR	0-28.665	28.665-57.33	57.333-86
COCE	0-27	27-54	54-81
CPLA	0-13.335	13.34-26.66	26.665-40
CSCU	0-13.665	13.66-27.33	27.33-41
DMAU	0-4	4-8	8-12
NPRE	0-6.335	6.34-12.66	12.665-19
NROT	0-8	8-16	16-24
NSROT	0-10.335	10.33-20.66	20.665-31
STPNN	0-7	7-14	14-21

In fact, the both techniques can be merged in order to improve the overall prediction accuracy of diatoms-environment relationship.

The induction process is very simple. First we divide the data into two groups, but maintaining into a single file, the TOP10 diatoms abundance data and three water quality classes from measured SatO, pH and Conductivity parameters

Sensor networks with QoS provisioning in Lake Prespa (1)

- Implementing sensor networks:
  - the on-demand necessity of measured parameters (collected in real-time and distributed to the main data centre for further processing)



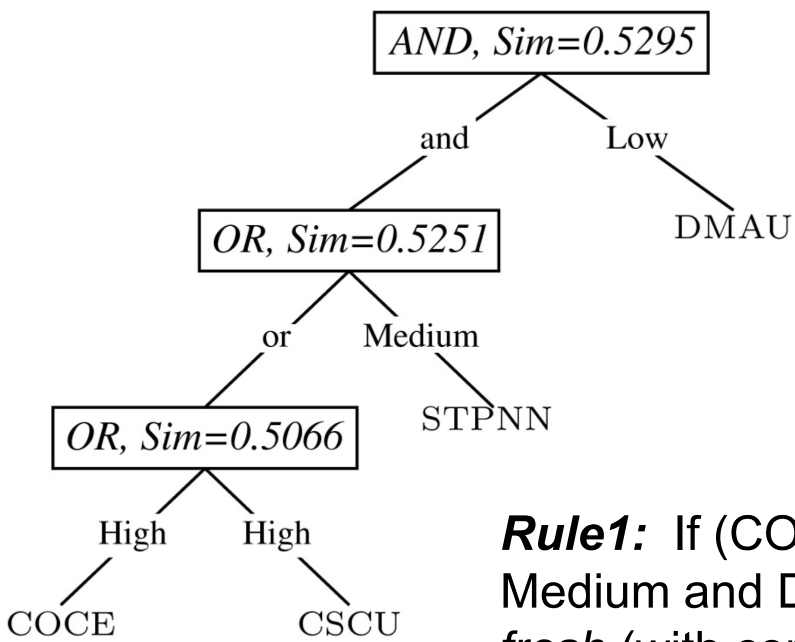
Locations of proposed sensor networks in Lake Prespa

Sensor networks with QoS provisioning in Lake Prespa (2)

- Advantages of sensor networks:
  - relatively small power consumptions, infrastructure-less, self-configuration, mobility, anytime-anywhere deployment and etc.
- QoS provisioning for this kind of networks is a very desirable objective.
  - measured result must be instant delivered to the dynamic model.
- Disadvantages:
  - limited bandwidth, increased errors from physical obstacles, interference from other devices, channel fading, low degree of scalability.

Experimental Results

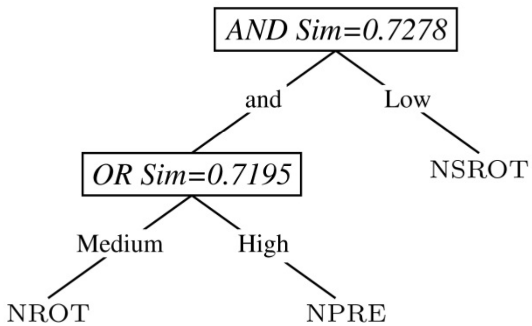
- In this work, we induce a general pattern tree which consists from 2 candidate trees, 3 low level trees and depth = 3.
- For similarity definition, we use RMSE similarity and only AND and OR for fuzzy aggregation procedure.
- We use three simple evenly distributed membership function from each membership function (triangular, trapezoidal and Gaussian).



Pattern tree for Conductivity WQC- *brackish-fresh* (left)

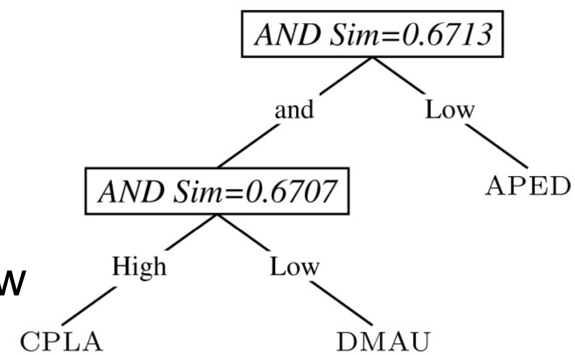
Rule1: If (COCE is High or CSCU is High) or STPNN is Medium and DMAU is Low then the class is *brackish-fresh* (with confidence of 0.5295)

Experimental Results



Pattern tree for pH WQC – *circumneutrala* (right)

Rule2: If (NROT is Medium or NPRE is High) or NSROT is Low then the class is ***circumneutrala*** (with confidence of 0.7278).



Rule3: If (CPLA is High or DMAU is Low) or APED is Low then the class is ***β-mesosaprobous*** (with confidence of 0.6713)

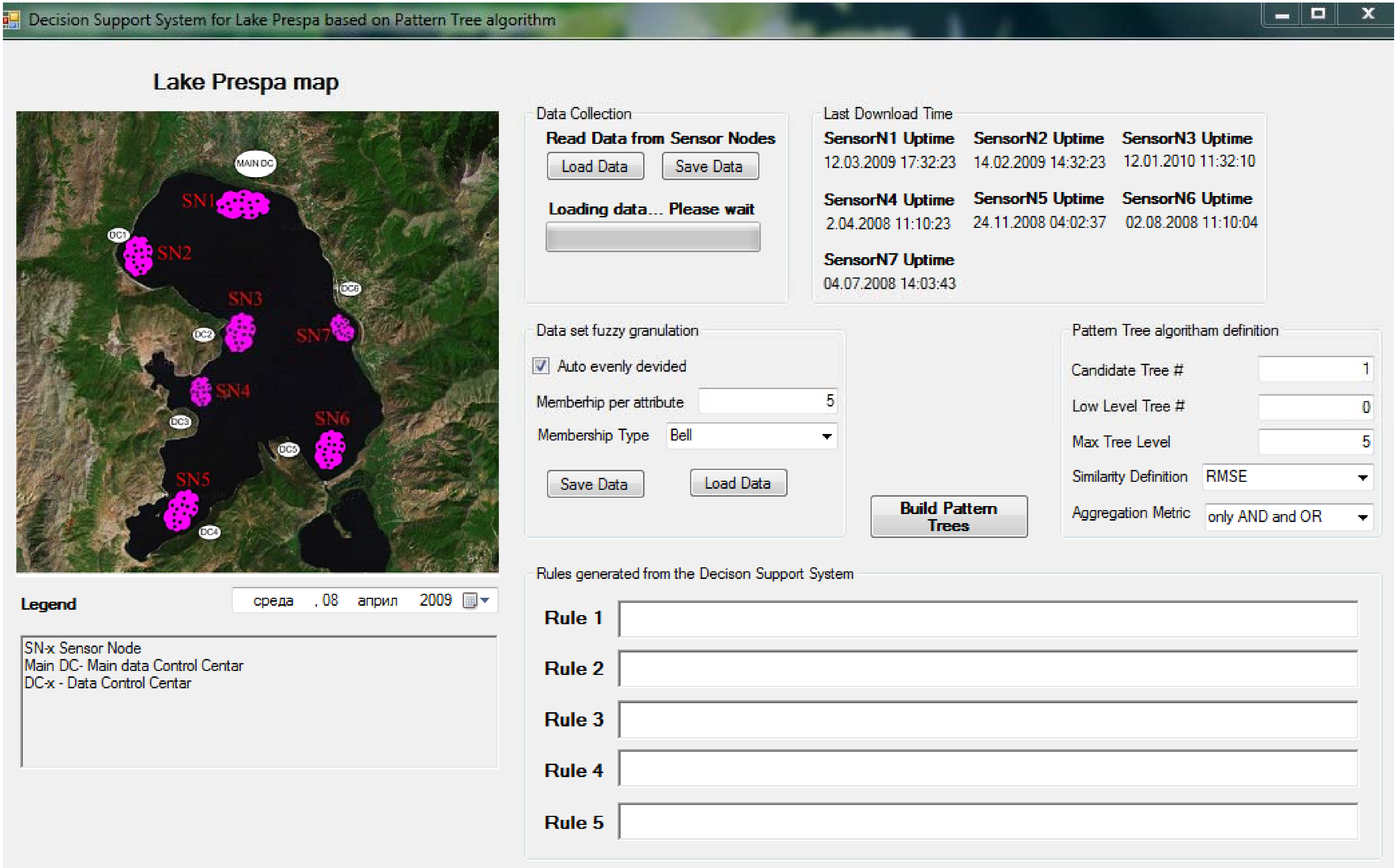
Pattern tree for pH WQC – *circumneutrala* (right)

Prediction performance

DataSet	C4.5	kNN	Bagging C4.5	Boosted C4.5	SPT5	SPT10	PT5	PT10
Conductivity 10-cross xVal	65.60	66.51	63.30○	63.76	68.16	68.64	69.07	68.14
Saturate Ox. 10-cross xVal	54.73	47.26○	53.23	56.22	54.50	54.50	53.00	55.00
pH 10-cross xVal	55.50	46.33○	56.42	49.54	57.62●	57.16	56.73	56.28

●, ○ statistically significant improvement or degradation

Decision Support System for Lake Prespa



Conclusion

- In this paper, we have presented a conceptual model for integrating energy-efficient protocols for data transmission into the decision system support with a novel diatom classification algorithm in ecology.
- The energy-efficient algorithms, discussed in this paper, have several advantages, over the previously used algorithms in data transmissions.
- Even in hard requirements of the environment impose; the discussed protocols to have shown that are possible to reduce the energy consumption.
- In fact, many of the pattern trees, such as the tree presented with Fig. 3 clearly indicate that SatO WQC can be indicated with high abundance of CPLA.

Q&A Section

Any Questions?

Thank you for your attention