DIONIS: efficient monitoring system for vineyards

Wireless sensor networks & Small medium enterprises (WSN-SME): ProSense workshop, Ljubljana, May 19-21, 2010
Macedonia: Facts & Numbers

- Rich viticulture and distinguished history of winemaking
- 27,500 hectares of vineyards that produce considerable quantities of highest quality grape
  - 65% belongs to wineries, 35% to individuals
  - 98 millions liters wine per year (150 million kilograms of grapes)
  - 88 wineries
- Main varieties grown
  - Vranec (red) and Smederevka (white)
- Trend of wine export

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exported Wine (million €)</td>
<td>17.4</td>
<td>17.7</td>
<td>19.6</td>
</tr>
</tbody>
</table>

- Vranec, Zilavka, Kartoshija and Temjanika are successfully penetrating the Western - European market
Trend of wine production: Towards quality

- Production of wine and the land used for vineyards has decreased over the last 20 years according to the EC (European Commission) reports.

- A need for
  - Efficiency in vineyard capacity utilization
  - Stability in the grape growing process
  - Quality over quantity!

- Improving the wine manufacturing mechanisms
  - New equipment, automated systems…

- Improving the process of growing grapes
  - Optimization of the irrigation system ⇒ Efficiency
  - Prevention from grape diseases ⇒ Stability
  - Different conditions are required for different varieties ⇒ Quality
Precision Agriculture: Vineyards monitoring

- **Precision agriculture** ⇒ an emerging trend in the agricultural sector that includes *implementing new technologies* for
  - improvement of the crop production management and
  - agricultural decision making

- **Precision agriculture in vineyards** (particularly wireless sensor network technology) provides
  - continuous monitoring of the vineyards
  - enables in time **notice delivery** anytime and anywhere

- improves the yield and quality of grapes
- decreases the costs and reduces the use of pesticides
Existing implementations and experiences

- **Camalie Vineyards**: Napa Valley
  - Camalie Networks and Crossbow technology, USA
  - irrigation management, frost protection and powdery mildew management

- **VineSense**: Chianti region of Tuscany, Italy
  - Netsense, Italy
  - irrigation control; downy mildew, powdery mildew and botrytis protection; water stress and plant physiology; thermal characterization of the new plants

- **Climate Genie™**: Napa Valley
  - Grape Networks, California, USA
  - monitoring water, temperature, humidity and light

- **Agri-Sens**: Sula Vineyard, Nasik, India
  - SPANN Lab, IIT Bombay, India
  - monitoring temperature, humidity, soil moisture and soil temperature

- **Precise Water Monitoring**
  - Fruition Sciences, California, USA
  - irrigation optimization based on sap flow
Experiences: Camalie Vineyards

- Area of coverage: 1.58 ha
- Divided in 10 regions on the basis of the combination of vineyard, the soil type, exposition of sun and the climate
- Different quantities of water supply are used in distinct regions

1 - Sensor network is installed along with 3000 new plants
2 - Different conditions are considered for different grape types

<table>
<thead>
<tr>
<th>Years</th>
<th>Crop [t/ha]</th>
<th>Crop - total [ton]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-2004</td>
<td>0.63</td>
<td>1</td>
</tr>
<tr>
<td>2005</td>
<td>2.53</td>
<td>4</td>
</tr>
<tr>
<td>2006</td>
<td>6.00</td>
<td>8.4</td>
</tr>
<tr>
<td>2007</td>
<td>11.5</td>
<td>18.2</td>
</tr>
<tr>
<td>2008</td>
<td>6.13</td>
<td>9.68</td>
</tr>
<tr>
<td>2009</td>
<td>11.1</td>
<td>17.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years</th>
<th>Rain [cm]</th>
<th>Plants [number]</th>
<th>Water supply [thousand liters]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>/</td>
<td>342</td>
<td>70</td>
</tr>
<tr>
<td>2003</td>
<td>103</td>
<td>644</td>
<td>1091</td>
</tr>
<tr>
<td>2004</td>
<td>65.8</td>
<td>4200</td>
<td>819</td>
</tr>
<tr>
<td>2005</td>
<td>94.5</td>
<td>4200</td>
<td>677</td>
</tr>
<tr>
<td>2006</td>
<td>97.5</td>
<td>4200</td>
<td>726</td>
</tr>
<tr>
<td>2007</td>
<td>46.2</td>
<td>4200</td>
<td>573</td>
</tr>
<tr>
<td>2008</td>
<td>58.2</td>
<td>4200</td>
<td>684</td>
</tr>
</tbody>
</table>

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Distributed and Intelligent system for monitoring vineyards with sensor networks

Facilitating better vineyard management with:

- **sensor system**
  - observing the vineyards specific conditions

- **visualization system**
  - monitoring the quality and vitality of the grapes in a vineyard
    - the need of water supply
    - the need of applying pesticides

- **alarm system**
  - providing alarm messages if some conditions require urgent reaction
  - thus improving the yield and quality of the crop

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DIONIS: Sensor system

- **Sensor network** features 24/7 observation of the vineyard specific conditions that can affect the grapes growing process

  - **Irrigation optimization**
    - soil moisture, sap flow, rainfall, temperature, humidity

  - **Drought and frost prediction**
    - temperature and air humidity

  - **Disease prevention**
    - leaf wetness, temperature, humidity, rainfall, UV radiation, wind speed

  - **Soil quality**
    - chemical composition of the soil

Temperature, humidity

Soil moisture

Leaf water potential

Solar radiation

Sap flow

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**DIONIS: Visualization system (1/2)**

- **Web Application** provides remote vineyard monitoring
  - the overall **data flow** of the Web Application:

  - **Mesh Tier**: Data is generated by the sensors mounted in the vineyard, then transmitted for further processing.
  - **Server Tier**: Data is collected, filtered and classified in a Database for further analysis.
  - **Client Tier**: Data is fetched and presented in a user-defined manner.

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Main features of the application interface

- Graphical representation of the processed data, as well of the vineyard itself
- Configurable Graphs – daily, weekly, monthly graphs that can be configured

Alarm messages – accordingly to the configured parameters

Topographic View of the vineyard and the mounted sensors

Configurable Graphs for data analyzes, data comparison & planning

Alarm messages - can be configured and sent to various devices:
- App listing
- SMS Message
- e-Mail
- Other ways
DIONIS: Process of implementation
DIONIS Beneficiary:
Private winery - Popova Kula

Popova Kula winery: www.popovakula.com.mk

CNN news: Creating Napa Valley in Macedonia
Implementation constraints?

- Electricity sources proximity
- Buildings proximity
- Distance between measurement points
- Vineyards size
- Equipment depreciation

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Conclusion (1/2)

- Vineyards monitoring is an invaluable factor in increasing the production and quality of grapes cultivation
- Sensor networks are the solution of the future
  - Application in many diverse areas: greenhouses, floriculture, fruit growing etc.
  - Implementation in the most successful wineries in France, California, South Africa etc.
- The implementation of the sensor networks in vineyards means:
  - 24h monitoring of the vineyard micro-climate conditions
  - Remote access to the vineyard monitoring system
  - Alarm notifications
Conclusion (2/2)

- **DIONIS** project
  - application of sensor networks in vineyards monitoring
  - the ICT knowledge as a support in agriculture
  - cooperation between academia and SME

- **DIONIS** implementation
  - Popova Kula winery (first phase of DIONIS implementation)
  - Extending the project for
    - monitoring and automation of the wine cellars, wineries
    - and wine production processes
    - implementing diverse sensor network solutions ...
About us…

WinGroup & ECS

- **WiN Group** (Wireless Networks Group) is a research activity oriented group, specializing in wireless and mobile networking
  - Founded in September 2007 as part of the FEEIT - Skopje
  - The group participates in many national and international (EU FP7) projects: ProSense, ARAGORN, RIWCoS, QUASAR, FARAMIR, etc.

- The relevant experience in the field of Wireless Sensor Network is gained in EU FP7 project ProSense
  - In the scope of the project, sensor network equipment is purchased and diverse applications are developed
  - [http://prosense.feit.ukim.edu.mk](http://prosense.feit.ukim.edu.mk)

- **ECS** (EuroComputer Systems)
  - Established in 1991
  - One of the most successful IT companies in the Republic of Macedonia participating in a number of system integration projects
WiNGroup & ECS

Testbed platforms

Equipment & GUI

FEEIT-ECS Collaboration agreement

Thank you for your attention

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