

Wireless Sensor Networks for an Information Technology-Driven Viticulture and Vinification

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Abstract

Wireless Sensor Networks is one of latest trending technology because of its wide array of usage in various fields. This article talks about related studies and literature regarding WSN applications in agriculture and in the winemaking industry. Specifically, this study focuses on how WSNs can help in grapevine cultivation and grape wine production. Furthermore, a list of the most popular cultivars of grapes was provided as well as their respective other known names. Because of the fact that these varieties of grapes are the most desired by the people, WSNs will probably be utilized frequently in these cultivars in order to maintain quality and increase the quantity of products to meet the demands of consumers.

Keyword: Wireless Sensor Networks, Viticulture, Vinification

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1. Introduction

Grapes is one of the most important agricultural products worldwide [1]. The raw fruit can be consumed anytime, it can be made into raisins, juice, jam and it can also be used for ethanol production. But what makes it a more in demand product is that it is being used to make a wine. Wine is an alcoholic beverage made from fermented plants and fruits [2]. Of all types of wines, the one made from fermented grapes is commonly consumed by the people [3].

Viticulture is the science, technology, production and study of grapes [4]. This furthermore involves environment monitoring, irrigation management, pest control, soil fertilization, plant growth and fruit development monitoring.

Traditional viticulture practices went well, but problems could sometimes be uncontrollable due to lack of knowledge about these problems. Past experiences and additional knowledge about many factors that could affect grapevine agriculture has led to the modern viticulture practices which employs technology in order to improve plant growth and increase plant productivity. Improvement of quality and increase in quantity of grapes to be harvested gives a good raw material for wine making [15].

The winemaking process is known as vinification. The basic processes involved are harvesting and destemming, crushing, fermentation, aging, blending, clarification and bottling [5,6,7].

Traditional vinification involves manual work in the processes mentioned lately. With technology, modern vinification practices deploys machines and gadgets in the vineyard for grape harvesting and in the winemaking factory for destemming, crushing, fermentation, aging, blending, clarification, bottling and other processes deemed necessary by the business entity [16]. These things can help save time and improve quality of products [17].

One of the latest trends in technology is the Wireless Sensor Networks (WSNs). This technology enables wireless connectivity within a system by linking an application platform at one end of the network with one or more actuator devices in any part of the network [18]. WSNs can provide many functions for agricultural practices [1] as well as in the winemaking procedures [19].

2. Review of Related Literature

This section shall cover past studies and literatures relating to technologies and techniques applied in agricultural management as well as industrial production management.

In the field of agriculture, especially in plant growth and environment monitoring, many technologies can be of help such as canopy monitoring, remote sensing systems, ground-based and soil monitoring systems [15]. WSNs, being one of these technologies, collect data from the plants as well as their environment and forward it to the server where raw data are being organized to create information useful in decision making [20].

Plant growth monitoring is important in agriculture. Knowing, the growth level plants will tell you how much nutrients and water will be needed for their further development and yield production [25]. Liqiang, et al., designed a WSN that gathers crop growth images in Beijing [26]. Aside from crops, researchers in India also designed a WSN-based tree-monitoring by utilizing GPRS as well as photosynthetically active radiation sensor, microcontroller and bridge rectifiers. Their system was programmed that when a canopy growth reaches a defined threshold measurement value a message will be displayed in the printed circuit boards, and a notification through short message service will be sent to the owner's mobile phone. [27]. There are also WSNs used for fruit monitoring. In the study of Krairiksh et al., sensor networks were used to detect the maturity of durian fruit [30].

Environmental monitoring is also important. That's why WSNs are also deployed to acquire environmental parametric data from water, air and soil [1]. Water monitoring as well as irrigation management is important for plant growth. Each type of plant has its own water requirement. When water is not enough or too much for the plant, it can create stress which can interfere with photosynthetic activity and reduce the potential growth of the plant [22]. In the study of Lea-Cox et al., WSNs were utilized for irrigation, nutrient management and frost protection of strawberries [23]. In the study of Simon and Jacob, sensor networks were also utilized for water level monitoring in the paddy fields in order to have good crop yield [24]. In addition water pH level must also be monitored [28]. Along with irrigation

management is the soil monitoring, soil moisture data transmitted through the sensor networks will help in the amount of water to be irrigated to the plants [29]. Air humidity is also important to plant growth [23,26]. All plants draw in carbon dioxide through their leaves for their photosynthesis. As the plant opens its leaf pores to take in carbon dioxide, some of the moisture in the leaf can escape. Thus the plants secrete water vapor into the air whenever they respire [31].

In the study of Valverde et al., WSNs were used for a real monitoring application in an instant coffee factory. The industrial processes involved in the factory can both create harmful gas emissions and polluted water discharges. To ensure that the factory has a safe environment for workers and that it is in compliance with the environmental laws, they have deployed devices to monitor emissions which are harmful to human and other living things in the environment [21].

The usage of wireless sensor networks in the industry does have security threats such as Denial of Service, wormhole, Sybil, hello flood and sinkhole. But these things may be countered through incorporation appropriate defense mechanisms such as encryption, authorization, certificate identification, and other detection techniques [32]. When deployed, the connectivity of these WSNs can easily be monitored [33]. When applied in farming especially in growing environment monitoring, these tools can be installed in various methods depending on the farming system [33]. Employing WSNs in the vineyard means additional costs, so this technology must be used wisely.

3. Grape Varieties

Grapes can be propagated by seeds or cuttings and they may have unstable reproductive properties which results to different varieties. Table 1 is a list of the popular varieties of grapes which are commonly being used for wine production [8] and their other known names [9-14].

[Table 1] Top Varieties of Grapes being used for Wine Production

Common Name	Other Names
Cabernet Franc	Acheria, Ardounet, Aroia, Arrouya, Auxquels, Baro, Beron, Bidure, Bordeaux, Bordo, Bordo Maghar, Boubet, Bouchet, Bouchet Franc, Bouchet Saint-Emilion, Bouchy, Breton, Burdeas Tinto, Cabernet, Cabernet Aunis, Cabernet Bresciano, Cabernet D'Aunis, Cabernet Franc Blauer, Cabernet Franc Crni, Cabernet Franc Nero, Cabernet Franc Noir, Cabernet Francese, Cabernet Franco, Cabernet Frank, Cabernet Gris, Cabonet, Cabrunet, Capbreton, Capbreton Rouge, Carbenet, Carbonet, Carbouet, Carmena, Carment, Carment Grand, Carne Fran, Couahort, Crouchen Negre, Crouchen Noir, Fer Servadou, Fer Servadou, Gamput, Gro Kaberne, Gro Vidyur, Gro Vidyur, Gros Bouchet, Gros Bouschet, Gros Caberne, Gros Cabernet, Gros Vidure, Gros Vidyur, Grosse Vidure, Hartling, Kaberne, Kaberne Fran, Kaberne Frank, Kabernet Frank Breton, Karmene, Messanges, Messanges Rouge, Morenoa Veron Bouchy, Noir Dur, Petit Fer, Petit Vidure, Petite Vidure, Petite Vignedure, Plan Des Sables, Plant Breton, Plant De L'Abbe Breton, Qro Kaberne, Qro Vidyur, Sable Rouge, Trousset, Trousset Noir, Tsapournako, Verdejilla Tinto, Veron, Veron Bouchy, Veronais, Vidure, Vuidure
Cabernet Sauvignon	Bidure, Bordaoux, Bordeaux, Bordo, Bouche, Bouchet, Bouchet Sauvignon, Bourdeas Tinto, Bouschet Sauvignon, Breton, Burdeas Tinto, Cabernet Sauvignon, Caberne, Caberne Sovinion, Cabernet Petit, Cabernet Piccolo, Cabernet Sauvignon Black, Cabernet Sauvignon Blauer, Cabernet Sauvignon Cl. R5, Cabernet Sauvignon Crni, Cabernet Sauvignon Nero, Cabernet Sauvignon Noir, Cabernet Sauvignon Petit, Carbonet, Carbouet, Carment, Castet, Dzanati, Enfin, Epicier Noir, Kaberne Sovinjon, Kaberne Sovinon, Kaberne Sovinyon, Kabernet Suvinjon, Lafet, Lafite, Marchoupet, Melkii Chernyi, Menut, Navarre, Petit Bouchet, Petit Bouschet, Petit Cabernet, Petit Cabernet Sauvignon, Petit Vidure, Petit-Bouchet, Petite Perde, Petite Vidure, Sauvignon, Sauvignon Rouge, Sauvignonne, Vaucluse, Veron, Vidure, Vidure Petite, Vidure Sauvignon, Vidure Sauvignonne
Carmenere	Bordo, Bouton Blanc, Caberna Karmener, Cabernalla, Cabernella, Cabernet, Cabernet Carmenere, Cabernet Cosmo, Cabernet Gernicht, Cabernet Gemischt, Cabernet Gernischt, Cabernet Gemiseht, Cabernet Grande, Cabernet Grosso, Cabernet Italico, Cabernet Shelongzhu, Carbonet, Carbouet, Caramenella, Carmenea, Carmenegre, Carmenella, Carmeneyre, Gran Vidyur, Grand Carment, Grand Vidure, Grande Vidure, Grande Vuidure, Grosse Vidure, Kaberne, Kaberne Karmener, Kabemel, Karmene, Karmensel, Uva Francesca
Chardonnay	Arboisier, Arnaison blanc, Armoison, Aubain, Aubaine, Auvergnat blanc, Auvernas, Auvernas blanc, Auvernat blanc, Auxeras, Auxerras blanc, Auxerrois blanc, Auxois, Auxois blanc, Bargeois blanc, Beaunois, Biela Klevanjka, Blanc de Champagne, Blanc de Cramant, Breisgauer Süssling, Breisgauer Süssling, Burgundi Feher, Chablis, Chardenai, Chardenay, Chardenet, Chardennet, Chardonnay, Chardonnat, Chateauf, Chatey Petit, Chatte, Chaudenay, Chaudenat, Chaudent, Clavner, Clevner Weiss, Cravner, Epinette, Epinette blanc, Epinette blanche, Epinette de Champagne, Ericey blanc, Feher Chardonnay, Feherburgundi, Feinburgunder, Gamay blanc, Gelber Weissburgunder, Gentil blanc, Grosse Bourgogne, Klawner, Klevanjka Biela, Klevner, Lisant, Luisant, Luzannais, Luzant, Luzannois, Maconnais, Maurillon blanc, Melon blanc, Melon D'Arbois, Meroué, Moreau blanc, Morillon blanc, Moulon, Noirien blanc, Obaideh, Petit Chatey, Petit Sainte-Marie, Petite Sainte Marie, Pineau blanc, Pino Sardone, Pino Shardone, Pinot Blanc à Cramant, Pinot Blanc Chardonnay, Pinot Chardonnay, Pinot de Bourgogne, Pinot Giallo, Pinot Blanc, Plant de Tonnerre, Romere, Romeret, Rouci Bile, Rousseau, Roussot, Ruländer Weiss, Sainte Marie Petite, Sardone, Shardone, Shardonne, Später Weiß Burgunder, Weiss Burgunder, Weiss Clevner, Weiss Edler, Weiss Elder, Weiss Klawner, Weiss Silber, Weissedler, Weisses Clevner, Weißer Ruländer
Gewurztraminer	Auvernas rouge, Blanc brun, Blanc Court, Bon blanc, Christkindeltraube, Christkindelstraube, Clevener, Clevner, Crevena Ruziva, Crovena Ruzica, Dišči Traminac, Dreimaenner, Dreimannen, Dreipfennigholz, Drumin, Drumin Ljbor, Duret rouge, Edeltraube, Fermentin rouge, Fleischroth, Fleischweiner, Formentin rouge, Fourmenteau rouge, Frencher, Fromente, Fromenteau, Füszeres, Füszeres Tramin, Gentil Rose Aromatique, Gentil-duret rouge, Gentile blanc, Gentie, Gewurztraminer, Gringet, Gris rouge, Haiden, Kirmizi Traminer, Klabinger, Klabvner, Kleinbraun, Kleinwiener, Livora, Livora Cervena, Mala Dinka, Marzimmer, Mirisavi Traminac, Nature, Nature rose, Noble rose, Nuernberger Rot, Pinat Cervena, Piro Tramin, Plant Paen, Princ Cerveny, Princ Cervena, Princ Cerveny, Ranfoliza, Rosentraminer, Rotclevner, Rotdel, Roter Nuernberger, Roter Nuernberger, Roter Traminer, Rotfranken, Rothklausner

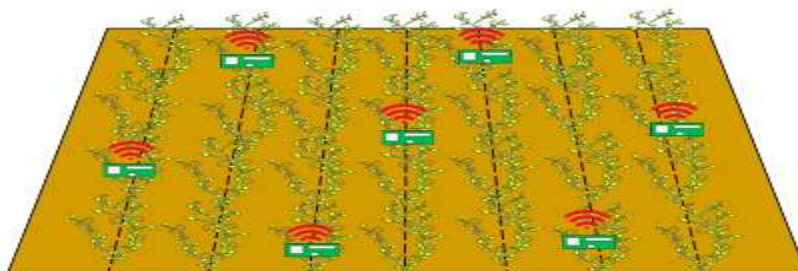
	Rothweiner, Rothwienar, Rotklaubler, Rotklaubner, Rotklevner, Rousselat, Runziva, Russa, Rуска, Ryvola, Sauvagnin, Sauvagnin, Sauvagnin, Sauvagnin jaune, Sauvagnin Rosa Aromatique, Sauvagnin rose, Sauvagnin Rose Aromatique, Sauvagnin Rose Musque, St. Klausner, Termino Aromatico, Tramin Cerveny, Tramin Korenny, Traminac Cerveni, Traminac Diseci, Traminac mirisavi, Traminac Mirisavi Crveni, Traminac Sivi, Traminac, Traminer, Traminer Aromatico, Traminer Epica, Traminer Musque, Traminer Parfume, Traminer rosa, Traminer Rose Aromatique, Traminer Rot, Traminer Rozovyi, Trimini Piro and Trammener
Grenache	Abundante, Aleante, Aleantedi Rivalto, Aleante Poggiarelli, Alicante Blau, Alicante, Alicante Grenache, Aragones, Bois Jaune, Cannonaddo, Cannonadu Nieddu, Cannonau, Cannonau Selvaggio, Canonazo, Carignane rosso, Elegante, Francese, Gamay del Trasimeno, Gamay Perugino, Garnachcho negro, Garnacha Comun, Garnacha negra, Garnacha Roja, Garnacha tinta, Garnatxa negra, Garnatxa Pais, Gironet, Granaccia, Granaxa, Grenache noir, Grenache rouge, Kek Grenache, Liadoner, Mencida, Navaro, Navarra, Navarre de la Dordogne, Navaro, Negro Calvese, Ranconnat, Red Grenache, Redondal, Retagliadu Nieddu, Rivesalles, Roussillon Tinto, Roussillon, Rouvillard, Sans Pareil, Santa Maria de Alcantara, Tentillo, Tintella, Tintilla, Tinto Menudo, Tinto Navalcarnero, Tai rosso, Toledana, Uva di Spagna, and Vernatxa.
Malbec	Agreste, Auxerrois, Auxerrois De Laquenexy, Auxerrois Des Moines De Picpus, Auxerrois Du Mans, Balouzat, Beran, Blanc De Kienzheim, Cahors, Calarin, Cauli, Costa Rosa, Cot A Queue Verte, Cortes Rouges, Doux Noir, Estrangey, Gourdaux, Grelot De Tours, Griffotin, Guilan, Hourcat, Jacobain, Luckens, Magret, Malbek, Medoc Noir, Mouranne, Navarien, Negre De Prechac, Negrera, Noir De Chartres, Noir De Pressac, Noir Doux, Nyar De Pressac, Parde, Périgord, Pied De Perdrix, Pied Noir, Pied Rouge, Pied Rouget, Piperdy, Plant D'Arles, Plant De Meraou, Plant Du Roi, Prechat, Pressac, Prunieral, Quercy, Queue Rouge, Quille De Coy, Romieu, Teinturin, Terranis, Vespardo, Côt, Plant du Lot
Merlot	Alicante, Alicante noir, Bégney, Bidal, Bidalhe, Bigney, Bigney rouge, Bini, Bini Ruzh, Bioney, Black Alicante, Bordeaux belcha, Crabutet, Crabutet noir, Crabutet noir merlau, Hebigney, Higney, Higney rouge, Langon, Lecchumskij, Médoc noir, Merlau, Merlaut, Merlaut noir, Merle, Merle Petite, Merleau, Merlot, Merlot noir, Merlot black, Merlot blauer, Merlot crni, Merlot nero, Merlot, Merlot, Odralski, Odralski, Odralski, Odralski Legkhumskii, Petit Merle, Picard, Pikard, Plan medre, Planet Medok, Plant du Médoc, Plant Médoc, Saint-Macaire, Same de la Canan, Same dou Flaube, Sème de la Canau, Sème Dou Flube, Semillon rouge, Semillon rouge, Semillon rouge, Semillon rouge, Sud des Graves, Vidal, Vini Ticinesi, Vitrai and Vitraile
Muscat Ottonei	Chasselas Saint Pierre, Mirisavka, Mirisavka, Misket Ottonei, Moscato Ottonei bianco, Moscato Ottonei, Moscatos, Mozzonai, Muscadell Ottonei (in South Africa), Muscat Ottonei blanc, Muscat Ottonei White, Muscat Ottonei, Muscat Ottonei Weiss, Muscats, Muskat Ottonei (in Bulgaria), Muskat Ottonei Bijeli, Muskat Ottonei Weiss, Muskat Ottonei (in Austria, Germany and Slovenia), Muskotály, Muskotály, Ottonei, Ottonei Frontignan, Ottonei Muscotally, Ottonei Muskotály, Tâmbioasă Ottonei, Muscat de Cractonel Tirnave and Tâmbioasă Ottonei.
Nebbiolo	Barbesino, Brunenta, Femmina, Lampia, Marchesana, Martesana Melasca, Melaschetto, Melascone, Michel, Monferrina, Morsano di Caraglio, Nebbiol grosso, Nebbiol Maschio, Nebbiolin, Nebbiolin Canavesano, Nebbiolin lungo, Nebbiolin nero, Nebbiol, Nebbiol, Nebbiol fumela, Nebbiolo, Nebbiolo du Piedmont, Nebbiol burghin, Nibio, Nibiol, Nubiola, Pantin, Picot, Picotendre, Picote, Picotenero, Picotulener, Picotulender Maschio, Pocte, Prugnet, Prunent, Prunenta, Pugnet, Rosetta, Spagna, Span, Spana commune, Spana grossa and Uva Spanna.
Pinotage	Herminoir
Pinot Grigio	Grauburgunder, Malvoisie, Pinot gris, Pinot jaune, Szürkebarát
Pinot Noir	Aprofekere, Arbst, Arbst Blau, Arbst Blauer, Assmannshäuser, Augustiner, Auvergnat, Auvemas, Auvemas Rouge, Auvemat, Auvemat Noir, Auxema, Berligout, Black Burgundy, Black Morillon, Blak Burgundy, Blau Burgunder, Blauburgunder, Blauer, Blauer Augustiner, Blauer Burgunder, Blauer Clavner, Blauer Clavner, Blauer Clavener, Blauer Clavner, Blauer Clavner, Blauer Clavner, Blauer Nuernberg, Blauer Nuernberger, Blauer Rischling, Blauer Seeklevner, Blauer Späthburgunder, Blauer Sylvaner, Blaw Shpet Burgunder, Bodenseetraube, Bodenseetraube Blau, Boehmischer, Bon Plant, Borgogna Nera, Borgogna Nero, Borgogna Rosso, Bourignon, Bourignon Noir, Bourignon Noir, Bourignon Gros, Bourignon Noir, Bourignon Petit, Bruenlaubler, Burgunda, Burgundac Cemii, Burgundac Cmi, Burgundac Cmi Pozni, Burgunder, Burgunder Blau, Burgunder Blauer, Burgunder Grosse Blau, Burgunder Kleine Blau, Burgunder Roter, Burgunder Schwarz, Burgundi Cmi, Burgundi Mic, Burgundske Modre, Cerna Okrugla, Cerna Okrugla Banka, Cerna Ranka, Chambertin, Champagner, Cherna, Chiavennase, Chiavenna, Chpatchok, Clavner, Clavner Blau, Clavner Schwarz, Clavensis, Clavner, Cortailod, Derice Auvemas Noir, Dickblau, Echter Schwarzblauer Clavner, Elsasser Rot, Elsasser Rother, Fin Noir, Fin Noir De Toulon, Fin Plant Dore, Formentin Noir, Frankische Schwarze, Franc Noiren, Franc Noiren, Franc Pineau, Franc Pinot, Francois Noir, Frischschwarzer, Fruehblau, Fruehblauer, Fruehschwarzer, Fruehblauer, Gamais, Genetin De St. Manin, Gentil Noir, Glavinger, Glasschwarz, Gribalet Noir, Grobes Suesschwarz, Grosse Burgunder, Grosse

	Fruehschwarze, Gut Blau, Gubblau, Jakabszoele, Karapino, Kak Burgundi, Kak Kisburgundi, Kak Klevner, Kak Ruland, Kis Burgundi, Kis Burgundikek, Kisburgundi Kek, Kisburgundikek, Klevner, Klevner Schwarz, Klebroth, Klebroth, Klebroth, Kleine Burgunder, Kleiner Burgunder, Kleinrot, Kleinroth, Klavinger, Klevner, Klevner Kak, Klevner Schwarzblau, Korai Kakburgundi, Langadet, Maehrdchen, Maehrdinger, Maltetinger, Maria Feld, Marillon N, Massouet, Massouet, Maurillon, Mensois, Modra Burgunda, Modra Klevanja, Modra Klevanjka, Modra Klevanyka, Modri Pinot, Moehrdchen, Mohrenkoenigin, Mohrenkoenigin Fruehblau, Mor Burgunder, Moreote Noir, Moreotische Traube, Morillon, Morillon Noir, Nagyburgundi, Nere, Neyvan, Neyron Petit, Noble, Noble Jous, Noir De Franconier, Noir De Versich, Noir Menu, Noir Meun, Noiried, Noirien, Noirien Franc, Noirien Tement, Noirin, Noirin, Okrugla Ranka, Ordinaerer Blauer, Ordinaerer Rother, Orleans, Petit Noir, Petit Noirin, Petit Plant Dore, Petit Verot, Pignol, Pignola, Pignolet, Pignoliga, Pignolo, Pignola, Pimbart, Pineau, Pineau De Bourgogne, Pineau De Bourgoyne, Pineau De Chambertin, Pineau De Gevrey, Pineau Franc, Pineau Noir, Pino Black, Pino Ceren, Pino Cerni, Pino Cheren, Pino Chernyi, Pino Chernyj, Pino Corni, Pino Corni, Pino Corni, Pino Fran, Pino Go, Pino Negro, Pino Nero, Pino Nuar, Pino Qo, Pinot, Pinot Cerni, Pinot Clevner Cl. Maria- Feld, Pinot Crni, Pinot D'ay, Pinot De Chambertin, Pinot De Fleury, Pinot De Gevrey, Pinot De Migraine, Pinot Droit, Pinot Fin, Pinot Franc Noir, Pinot Mare, Pinot Mariafeld, Pinot Negro, Pinot Nera, Pinot Nero, Pinot Noar, Pinot Noir Cortailled, Pinot Noir Cortailled 9-18, Pinot Noir Salvagnin, Pinot Salvagnin, Pinot Tinto, Plack Morillon, Plant A Bon Vin, Plant Das, Plant De Cumieres, Plant De La Dole Noir, Plant De S. Martin, Plant Dore, Plant Fin, Plant Medaille, Plant Noble, Pynoz, Qara Pino, Raisin De Bourgogne, Raucy, Raucy Male, Roter Assmannshaeuser, Roter Assmannshaeuser, Roter Burgunder, Rother, Rother Assmannshaeuser, Rother Burgunder, Rouci, Rouci Male, Rouci Modra, Roucimodra, Rouget, Rulandske Modra, Salvagnin, Salvagnin Noir, Samoreau, Samoreau, Samrot, Saumensois, Saumoreau, Savagin Noir, Savagnin Noir, Schurz Riesling, Schwarz Klevner, Schwarz Traube, Schwarzblauer Klevner, Schwarze Franckische, Schwarzer, Schwarzer Assmannshaeuser, Schwarzer Burgunder, Schwarzer Champagner, Schwarzer Klevner, Schwarzer Klevner, Schwarzer Riesling, Schwarzer Riesling, Schwarzer Suessling, Schwarzer Tokayer, Schwarzklevner, Schwarzklevner, Schwarztraube, Savagnin Noir De Seyssel, Savagnin Noir, Shpachok, Shpachok, Shpachok, Shpachok, Spacok, Spaetburgunder, Spaetburgunder Blauer, Spaet Burgunder, Spaetes Moehrdchen, Spaetes Moehrdchen, Spatburgunder, Spatburgunder, Suessschwarz Grobes, Suessadel, Suessling, Suessrot, Suessroth, Suessschwarz, Suessschwarz, Suessschwarz, Suessadel, Suessrot, Suessschwarz, Talvagnere Rouge, Talvagnere Rouges, Ternant, Thalrother, Tinto, Traminer Blau, Traminer Schwarz, Vert Dore, Vrai Auvemas, Walteringer, Zuncic
Riesling	Beregi Riesling, Bayar Riesling, Biela Grasevina, Dinca Grasevina Biela, Edler Riesling, Edle Gewuerztraube, Feher Rajnai, Gentil Aromatique, Gentile Aromatique, Gewuerzriesling, Gewuerztraube, Graefenberg, Grasevina, Grasevina Rajnska, Grauer Riesling, Grobriesling, Hochheimer, Johannisberg, Johannisberger, Karbacher Riesling, Kastelberger, Kis Ritzling, Kleigebler, Kleiner Riesling, Kleinriesler, Kleinriesling, Klingelberger, Krauses, Krauses Roessling, Lipka, Mosler Riesling, Niederlaender, Oberkircher, Oberlaender, Petit Rhin, Petit Riesling, Petracina, Pfeiffer, Pfeiffer, Pinos Rajnai Ritzling, Pussilla, Raisin Du Rhin, Rajnski Ritzling, Rajnai Ritzling, Rajnski Ritzling, Rano, Reichriesling, Reissler, Remo, Rendu, Remo, Renski Ritzling, Rezlak, Rezlak, Rezlak, Rhein Riesling, Rheingauer, Rheinriesling, Rheinriesling, Riesler, Riesling bianco, Riesling blanc, Riesling De Rhin, Riesling Echer Weiss, Riesling Edler, Riesling Gelb Mosel E43, Riesling Giallo, Riesling Grosso, Riesling Gruener Mosel, Riesling Mosel, Riesling Reinskii, Riesling Rhenan, Riesling Rhine, Riesling, Ristinenok, Ristinenok, Ritzling Linner, Ritzling Rajnski, Ritzling Rajnai, Ritzling Rajnski, Ritzling Reinskii, Ritzling Rynsky, Roessling, Rohac, Roessling, Roessling, Ruessel, Ruessling, Russel, Ryn-Riesling, Ryzlink Rynsky, Starovetske, Starovetski, Szurke Ritzling, Uva Pussilla, Weiss Riesling
Sauvignon Blanc	Beyar Sauvignon, Blanc Doux, Blanc Fume, Bordeaux bianco, Douce blanche, Feher Sauvignon, Feigentraube, Fie, Fie dans le Neuvilleis, Fume, Fume Blanc, Fume Surin, Genetin, Gennetin, Gentin a Romorantin, Gros Sauvignon, Libournais, Mefkii Sotern, Muskat Silvaner, Muskat Sylvaner, Muskatani Silvaner, Muskatani Silvaner, Muskatani Silvaner, Muskatilsilvaner, Painechon, Pellegrina, Petit Sauvignon, Picabon, Picabon, Pinot Mestry Bely, Pissotta, Painechon, Painechon, Painechon, Quinechon, Rouchelin, Sempelgrina, Sarvonien, Sauternes, Sauvignon, Sauvignon bianco, Sauvignon Bijeli, Sauvignon blanco, Sauvignon Fume, Sauvignon Gros, Sauvignon jaune, Sauvignon jeune, Sauvignon Petit, Sauvignon vert, Sauvignon White, Savagnin, Savagnin blanc, Savagnin Musque, Savagnou, Savignon, Servanien, Servonien, Servoyen, Souternes, Sovinak, Sovinjon, Sovinjon Beli, Sovinon, Spergolina, Surin, Sylvaner Musque, Uva Pellegrina, Weiss Sauvignon, and Zeld Ortlibi
Semillon	Bamawartha Pinot, Blanc Doux, Blanc Semillon, Boal, Boal No Douro, Chevilier, Chevier, Chevier Blanc, Colombar, Colombaride, Colombarier, Daune Verte, Daune, Feher Semillon, Goulon Blanc, Goulou Blanc, Green Grape, Greengrape, Groendruif, Gros Semillon, Hunter River Riesling, Madeira, Maisois B, Malaga, Malaga Bianco, Mances Blanc, Mansois Blanc, Martillac, Monsois Blanc, Oron Semillon, Petit Semillon, Petrichtraube Weiss, Saint Semillon, Sauternes, Semijon, Semilao, Semilhao, Semillon, Semillon Bianco, Semillon Bijeli, Semillon Blanc, Semillon Blauen, Semillon Crucillant,

	Sémillon Fehér, Sémillon Grugillant, Sémillon Muscat, Sémillon Picolo, Sémillon Roux, Sémillon Weisser, Sémillon White, Sémillon, Sémilyon, Seminon, Sercial, Sotern, St. Emillion, Teisor, Wine Grape und Wynedruif
Shiraz	Antournerein, Antournerein Noir, Anzher Muskatnyi, Balsamina, Biauue Blau Schiraz, Blauer Syrah, Bragiola, Candive, Candive Noir, Costigliola, Costiola, Noir Dames du Puy de Doms, Damaszer Blau, Di Santi, Entournerein, Entournerein, Entournerein, Fressa Grossa, Hignin Noir, Marsanne Noir, Marsanne Noire, Marzane Noir Neiret di Saluzzo, Neiretta Cuneese, Neiretta del Cuneese-Fassanese, Neiretta del Monregalese, Neiretta del Rosso, Neiretta dell'albese, Neiretta di Saluzzo, Neiretto del Cuneese, Neiretto di Bana, Neiretto di Carru, Neiretto di Costigliola, Neiretto di Farigliano, Neiretto di Saluzzo, Nereta Piccola di Monre Galesa, Neretta Cuneese, Neretta del Cuneese-Fassanese, Neretta del Monregalese, Neretta di Costigliola, Neretta di Saluzzo, Neretta Piccola, Neretta Piccola di Dogliani, Neretto del Beinale, Neretto di Dogliani, Neretto di Saluzzo, Petite Sirrah, Petite Syras, Plan de La Biauue, Plant of Biauue, Plant of La biauue, Plant of La Biauue, serene, Serine, Schiras, Schiraz, Sereane, Sereine, Serene, Serenne, Serine, Serine Noir, Serinne, Sevene, Shiras, Shiraz, Shyrac, Sira, Sira, Sirah, Sirah Marsanne Noir, Syriac, Sirica, Syra, Syrac, Syrac de l'Ermitage, Syrah Cmi, Zizak
Tempranillo	Albillo negro, Aldepenas, Aragon, Aragones, Aragoner, Aragoner da ferra, Aragoner de elvas, Arauxa, Arganda, Arinto tinto, Cencibal, Cencibel, Cencibera, Chinchillana, Chinchillano, Chinchilyano, Crujidera, Cupani, De por aca, Escobera, Gamacho fono, Grenache de logrono, Jacibera, Jacibiera, Jacivera, Juan garcia, Negra de mesa, Negretto, Ojo de liebre, Olho de liebre, Palomino negro, Pinuela, Roriz, Sensibel, Tempranilla, Tempranillo, Tempranillo cmi, Tempranillo de la rioja, Tempranillo de perralta, Tempranillo de rioja, Tempranillo de rioza, Tempranillo rioja, Tinta aragones, Tinta corriente, Tinta de madrid, Tinta de santiago, Tinta de toro, Tinta del pais, Tinta do inacio, Tinta do pais, Tinta fina, Tinta madrid, Tinta monteira, Tinta monteiro, Tinta roris, Tinta roriz, Tinta santiago, Tinto aragon, Tinto aragones, Tinto aragoner, Tinto de la ribera, Tinto de madrid, Tinto de rioja, Tinto de toro, Tinto del pais, Tinto del toro, Tinto fino, Tinto fino de Madrid, Tinto madrid, Tinto pais, Tinto ribiera, Tinto riojano, Tinto tempranillo, Ull de liebre, Ull de liebra, Valdepenas, Verdiell, Vid de aranda
Viognier	Bergeron, Barbin, Rebolot, Creffou, Picotin Blanc, Vionnier, Petiti Vionnier, Viogna, Galopine
Zinfandel	Crljenak Kastelanski, Primitivo

4. WSN-based Viticulture

Viticulture deals with the production of grapes and this involves series of events happening in the vineyard. WSNs can be used in various processes during the grapevine development up to the grape fruit harvesting. This includes environmental monitoring, pest detection and controlling and of course – the plant growth and fruit monitoring. Figure 1 shows the deployment of wireless sensor networks in the vineyard.



[Fig. 1] Deployment of WSNs in the Vineyard

4.1. Environmental Monitoring

The environmental conditions are needed to be monitored in order to know the current situation of the grapevines in order to regulate water and nutrient needs. These tools things can help provide a real-time monitoring of grapevine environment by providing parametric data regarding the wind, atmospheric pressure, temperature, soil nutrient, pH levels, humidity, dew point, frost and rainfall. Many other environmental monitoring tools may also be linked with the sensors.

Temperature and radiation can affect the sugar level and ripeness of fruits. Data about air humidity can help prevent the development of fungi on the leaves and stem of the plant. The wind and temperature as well as soil moisture is also monitored for proper irrigation management.

4.2. Pest Management

Pest infestation is one of the common problems in viticulture. Mites, worms, caterpillars, moths and bugs are naturally in the environment but too much volume of these organisms can harm the grapevine and thus affecting fruit production. There are WSNs which has the ability to detect the specific type of pest that infests the vineyard. Data regarding this is transmitted to the server which helps the management to react immediately and perform pest infestation prevention actions.

4.3 Plant Growth Monitoring

Knowing the growth stage of the grapevine can help the management in deciding the amount of fertilizer and the level of water needed by the plants. WSNs can help with this which may lead to an effective production. In addition, there are also sensors that transmit fruit data and informs the management when the grapefruit is ready for harvesting.

5. WSN-based Vinification

Wine quality may be affected by many factors. One is the quality of the grapes harvested. But having a good quality of fruit is not enough. The vinification process is also a factor that contributes to the quality of the product being produced. Basically, vinification involves stem and fruit separation, fruit crushing, fermentation, aging, blending, clarification and bottling. During the winemaking process, there are complex series of chemical and physical reactions that transforms grapes into wine.

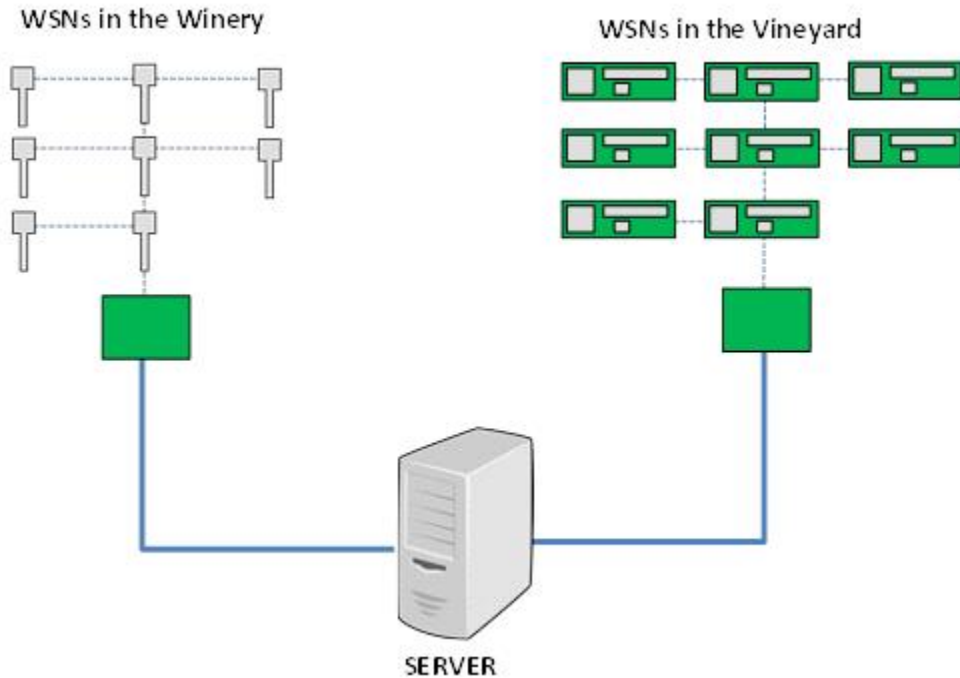
The industrial applications of WSNs in the vinification are focused on the monitoring of the parameters for wine fermentation and production. Temperature in the fermentation process can greatly affect the quality of the wine as this affects the fermentation process where the yeasts transform the sugar into alcohol and carbon dioxide.

Figure 2 shows the sensors attached in barrels in the winery. These sensors can measure the temperature, humidity, level of the wine in the barrel and pressure to control the fermentation process.

Figure 3 shows the system architecture of using wireless sensor networks in the vineyard and in the winery.



[Fig. 2] Deployment of WSNs in the Winery



[Fig. 3] The System Architecture

6. Conclusion

The presence of wireless sensor networks can help improve processes in cultivating grapevines, production of grape fruits and processing wines. The different varieties of grapes which may have varying monetary and economic value can be produced at its maximum quality and quantity because of the proper monitoring with help of WSNs. The winemaking process can be monitored in real time; this is faster and simpler than the traditional monitoring processes. Since this is a form of business, as a general rule, the cost involved in the utilization of WSNs must not exceed its benefits to be profitable. For sure there are many low-cost WSNs in the market available for owners or administrators of vineyards and wineries.

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