INNOVATIVE WIRELESS SENSOR FRAMEWORK FOR ENHANCED CHARACTERIZATION OF OIL AND GAS RESERVES IN KAZAKHSTAN

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Introduction. This research will develop a broad foundation in support of innovative wireless smart sensing strategies and technologies that can provide high-resolution subsurface seismic surveys to enable more effective exploration of the oil and gas reserves in Kazakhstan. The hypothesis is that next generation wireless smart sensor networks, coupled with UAV (Unmanned Aerial Vehicle) technologies, can create an autonomous seismic survey system that is scalable to large geographical regions and terrains of interest. The UAV will be employed as an airborne base station to provide cooperative wireless transmission for sensor nodes and data harvesting. Digital mapping of the exploration area will take advantage of the UAV's mobility, onboard computational power, and image processing capabilities. A key benefit of the proposed solution is its ability to scale to mega-node networks, yielding an unprecedented level of resolution for seismic surveys.

Seismic survey and its importance. Seismic surveys are one of the several geophysical tools that provide information about oil and gas reserves, directing intense low frequency sound signal into the ground to investigate subsurface condition, detecting possible high concentrations of reserves. Receivers called geophones, which convert ground velocity into an electric signal, pick up scattered waves that are reflected off of the subsurface, allowing the intensity and time of the signal to be recorded. Such sensing and recording are referred to herein as seismic data acquisition. The gathered signal is processed and converted into images of the geologic structure; this visualized topological structure is termed a "seismic image".

Advance in Seismic Survey Technology. The most important developments are the three-dimensional (3D) seismic acquisition and four-dimensional (4D) or time-lapsed seismic data that monitors how reservoir properties such as fluids, temperature and pressure changes during the production life of a field. In addition, multi-metric (3-axis) sensing, which record and utilize both compression (P) and shear (S) wave modes, has been shown to give superior images of the subsurface as compared to single component sensing .

Shortcoming on the traditional seismic data acquisition. A very important factor in the quality and resolution of the seismic image is the density of sensors in the array; i.e., a dense array of sensors provides sharper and clearer seismic images. The vast majority of seismic acquisition systems still rely on cable-based architectures that inherently limit the density of sensors and are quite costly. A current cable-based system usually requires hundreds of kilometers of cabling, often resulting in delays, high logistic costs, and low image quality. Recent technological advances, such as 3D or 4D seismic imaging, are difficult to realize with traditional cable-based systems due to cost and complexity. Wireless sensors offer the potential for addressing challenges faced by traditional cable-based systems.