



SPECTRUM MANAGEMENT IN PUBLIC AND GOVERNMENT SECURITY (P&GS) SYSTEMS; MAKING USE OF 'QUIET' TIMES

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- Introduction to P&GS systems
- Use case scenario/analysis and study
- Factors for Interoperability
- Different approaches for interoperability
- Requirements for interoperability between Commercial and P&GS systems
- Performance of short term spectrum negotiation in P&GS systems
- Summary

- Public and Government Security (P&GS) systems have the exclusive usage of licensed spectrum to provide communications for
 - local and state law enforcement authorities,
 - fire and emergency services,
 - critical health and safety personnel


Growth of Commercial Systems

- From commercial systems point of view growth of cellular and short range communication systems offer invisible but ubiquitous services that are essential for its services.
- User mobility and higher bandwidth requirements drive the advances in communication technology towards more demand on spectrum resources.

Future of P&GS and Commercial Systems

- It is essential for P&GS systems to manage its spectrum allocation more efficiently. Furthermore emergency service systems are needed to expand in terms of capacity, coverage and as well as in interoperability to make them more reliable and robust in emergency situations such as disaster monitoring.
- The WINTSEC project, a Preparatory Action on the enhancement of the European industrial potential in the field of Security research (PASR), investigates the possibilities and functionality required for wireless interoperability for security relevant communications.

Use case scenario

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- Analysis of a use case related to a disaster monitoring emergency situation is considered. The focus is on use of P&GS systems in a terrorist attack where the deployment of rapid Emergency Medical Services (EMS) is essential.
 - In the event of the above nature initially the Information Centre (IC) is set up by the Law Enforcement (LE) forces or first responders to the scene.
 - This gradually evolves into the Joint IC, a unified command centre which is responsible for forwarding information and data from the Core Network to the mobile terminals.
 - Public Safety Communications Office (PSCD) informs the IC of the staff status such as vital signs, location etc. This is a stand alone entity for each agency which makes its resource allocation/management more difficult. Vision of a unified command centre thus falls back to separate collocated command centre for each agency.

Factors for interoperability

- The data communication capabilities of EMS and other LE agencies may need to consider the following for interoperability between systems.
 - Information transfer from the perspective of the user rather than from the network providers' centric approach
 - Fast regain of control in crisis situations rather than the expected or anticipated situations
 - For fast regain of control increased data communication capabilities are needed
 - Current emergency systems does not guarantee data communication centric approach. The existing standards such as GPRS or current 3G systems does not guarantee reliability in terms of communications

Factors for interoperability


- Also in the case of disaster situations fixed communication structure (wire line or wireless) do not exists or either malfunctions
- In this respect systems with the following properties needs to be implemented
 - Support data communication
 - Ubiquitous coverage within the crisis area
 - Faster network deployment such as ad-hoc (instantly deployable wireless networks)
 - Guaranteed reliability
 - Robust techniques towards high security issues

Use case analysis

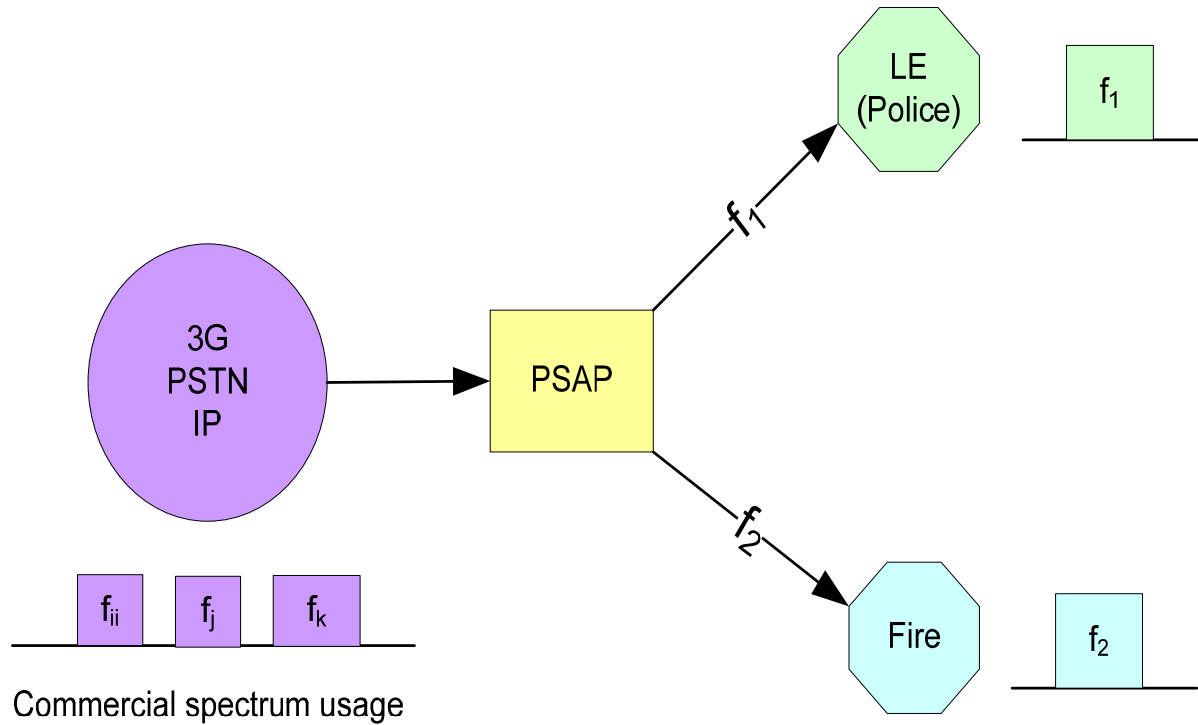
- Use case analysis is based on the above scenario with their transmission history attached to it containing parameters such as:
 - Time ID to give the time line and duration
 - Response information from Public Safety Answering Point (PSAP), Emergency Operations Centre (EOC), EMS etc...
 - Transmission information such as type and network utilization/security
 - Networks and comments indicating the involved networks in the scenario such as TETRA, TETRAPOL, 3G, Analog etc...

Use case study


- **Use case definition:** PSAP (emergency) calls received and contacts are made to dispatches
- **Time Stamp:** T_1
- **Actors involved:** PSAP, LE, Fire Services, Commercial Systems such as 3G, PSTN, IP systems
- **Use case description:** Public uses commercial networks such as 3G, PSTN and IP based networks to access the PSAP (Public Safety Answering Point). The first responder services are the LE and the Fire services which are informed by the PSAP.

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- Three different approaches are analyzed with respect to interoperability issues between P&GS systems and the commercial networks.
 - The first case looks into the current situation where there is no interoperability between systems.
 - The second case focuses on interoperability between P&GS systems is introduced using the cognitive radio approach.
 - Finally more ambitious and challenging case is presented where interoperability between P&GS systems as well as cognition among commercial systems are anticipated.

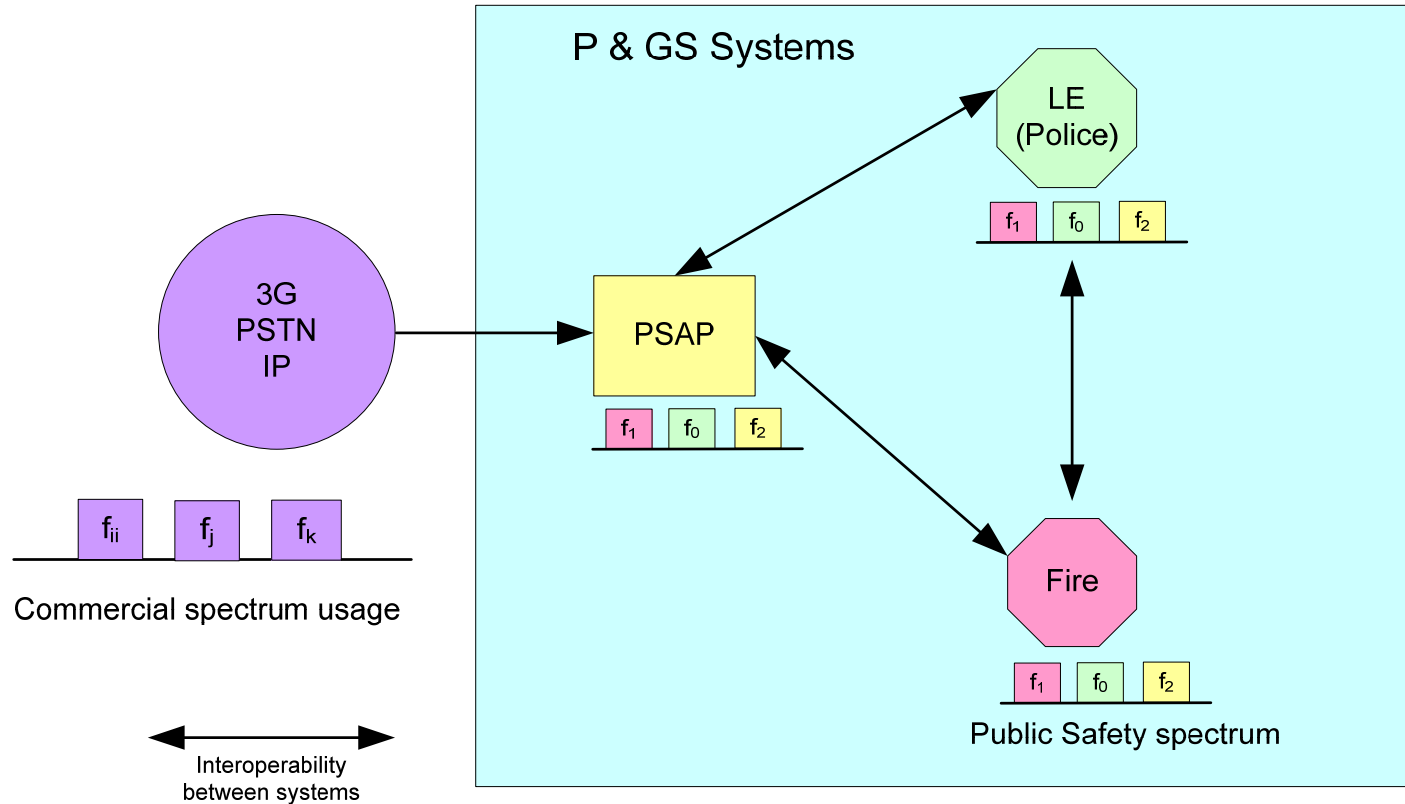
P&GS scenario without Interoperability



P&GS scenario without Interoperability

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- In this situation LE agencies and Fire services deploy their systems in different spectrum bands (frequencies f_1 and f_2).
 - In this case each agency will be using its own legacy public safety system technology hence the need of a communication centre for each system.
 - No automatic processing at LE agencies and no direct inter-agency communication. PSAP may need to communicate between the LE and Fire services separately as there is no direct communication between them.
 - On the other hand LE service and Fire service need to rely on the available capacity in commercial systems. But in disaster situations it is anticipated high volume of traffic in commercial systems. Also GSM/3G/UMTS may be even stopped by network operators to avoid the enemy usage.

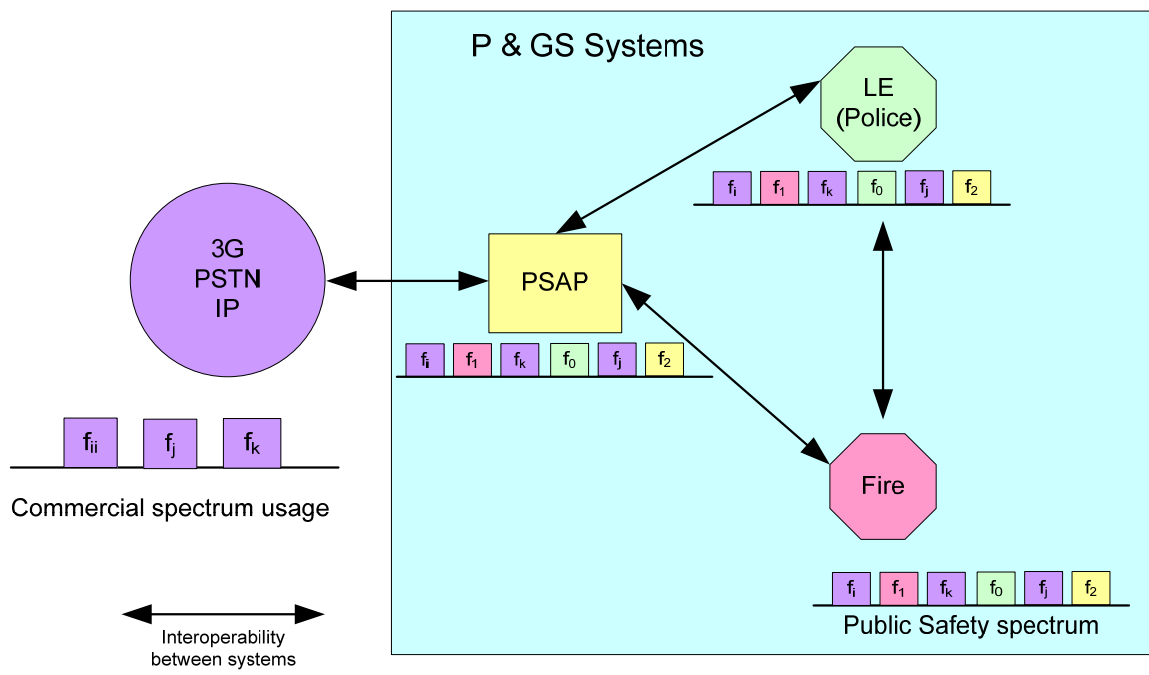
Interoperability between P & GS using cognitive approach



Interoperability between P & GS using cognitive approach

- The use of cognitive capability terminals reduces the problem of interoperability between law enforcement authority networks.
- Public safety systems (such as LE, Fire etc...) has the cognitive capability of tuning to other existing agencies introducing faster response times and efficient usage of the spectrum.
- This approach envisage a unified command centre achieved through the use of cognitive terminals which can be interoperated in each others' systems.
- The related issues of interoperability are that they need to be compatible with cognitive radio attributes such as spectrum sensing, policy based operations and ability to rapidly change operating frequencies, power, bandwidth and waveform.

Interoperability between Commercial and P&GS using cognitive approach



Interoperability between Commercial and P&GS using cognitive approach

- Commercial communication systems are more suitable for high bandwidth applications and more appropriate with mobility and coverage issues.
- One such instance is the use of commercial networks to transmit high data rate video applications (such as patient's visual images, injury status for medical operations etc...) used in EMS applications.
- Cognitive approach of commercial systems with P&GS may be used to bridge network boundaries providing seamless connectivity between legacy systems for public safety used across counties covering larger geographical areas of disaster situations.

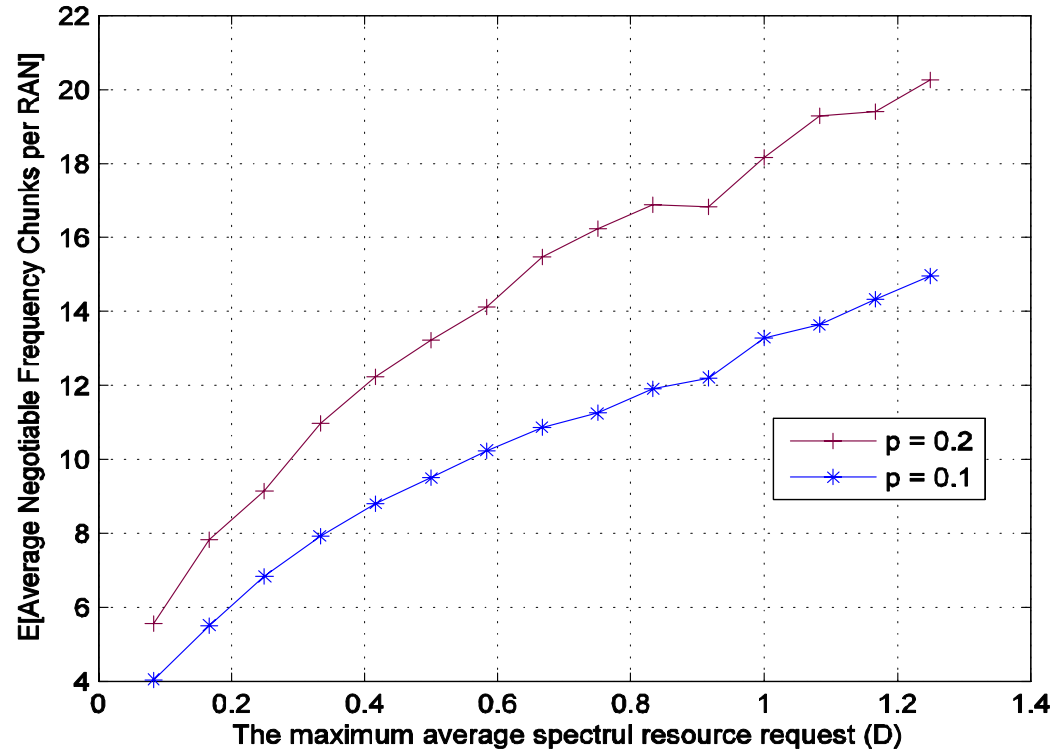
Requirements for Interoperability between Commercial and P&GS

- The following are some of stringent requirements that are necessary for robustness and reliability of public safety systems
 - not only the various systems and waveforms within the P&GS systems range are expected to interoperate,
 - but also P&GS systems and commercial as well as unlicensed systems will have to be able to communicate with each other.
 - Fast call set-up times;
 - group communications support;
 - direct mode operations between radios;
 - packet data and circuit data transfer services;
 - Excellent security features

Performance of short term spectrum negotiation in P&GS systems

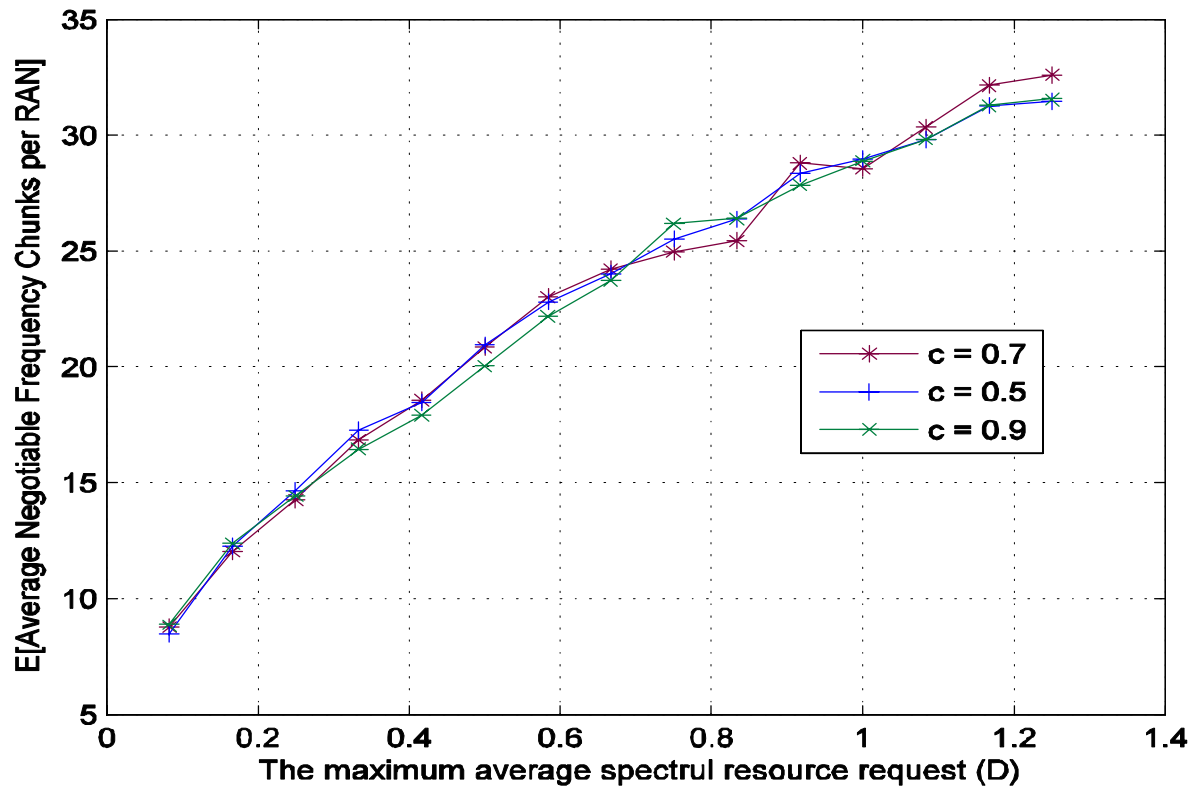
- Short term spectrum negotiation between P&GS systems is considered (similar to second approach)
- Two systems (RANs) are considered with its own assigned spectrum. During an emergency deployment both RANs are assumed to follow the similar traffic demand.
- The objective of this study is to investigate the impact of traffic parameters (variance and correlation factor) on spectrum negotiation between two RANs.

Impact of traffic variance for spectrum negotiation




- Average frequency resources available for negotiation
 - Different variance factors ($p = 0.1, 0.2$)
 - No correlation between RAN traffic

Impact of traffic correlation for spectrum negotiation



- Average frequency resources available for negotiation
 - different correlation factors ($c = 0.5, 0.7, 0.9$) and variance factor of $p = 0.5$

Summary

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- Key issues and the requirements that need to be addressed with the introduction of when flexible spectrum management into P&GS systems are studied.
 - Three different approaches are discussed based on use case study and analysis. Issues related to interoperability between P&GS systems are discussed with respect to each use case analysis.
 - Sensing requirements in terms of cognitive approaches are also discussed.
 - Spectrum negotiation between P&GS systems on a short term basis is investigated with respect to dynamic traffic parameters such as variance and correlation factor.
 - Even though the impact of variance of spectral resource request plays a major role in the successful spectrum negotiation, in the case of varying correlation factors it can be seen that traffic correlation does not play a major influence in spectrum negotiation.