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Abstract— Recently, a dynamic spectrum access technology has been in the spotlight for maximizing the utilization of the limited radio spectrum resource while accommodating the increasing amount of services and applications in the wireless networks. A cognitive radio is one of the key technologies based on dynamic spectrum manner. Although there have been many advances in cognitive radio with respect to the technology development, an additional research for the reformation of regulation, policy and market structure is still required to make CR-based dynamic spectrum access feasible and successful in the wireless market. Therefore, this paper classifies cognitive radio based network and application scenarios, and investigates feasibility of them. According to the analyses, this paper examines strategic approaches in the service providers, manufacturers', and policy makers' standpoints for the successful commercialization of cognitive radio with the dynamic spectrum management policy.

Index Terms— Cognitive Radio, scenario analysis, implementation issues, business model, dynamic spectrum management policy

I. INTRODUCTION

Recent developments in the wireless industries have led to a dramatic increase in spectrum demand, and this will expand further in future ubiquitous environments. According to an International Telecommunications Union (ITU) report, the estimated total spectrum bandwidth requirement for the year 2020 ranges from 1280 to 1720 MHz and, in the case of Korea, researchers estimate 2520 MHz as the total spectrum bandwidth requirement in that year. Although those estimates do not include LAN and broadcast systems, we will be forced to use our limited spectrum resource as efficiently as possible. Therefore, there have been many efforts to achieve this goal, not only in technology development but also in management policy. Given the necessity for spectrum management reform, a secondary trading market has been used as a mechanism to achieve more efficient spectrum use. Furthermore, an interest in spectrum sharing methods based on overlay and underlay sharing technologies has also increased. In particular, cognitive radio (CR) is a key technology that can utilize dynamic spectrum access (DSA) in an opportunistic manner so that service providers can share their unused spectrum resources and increase the efficiency of spectrum utilization. CR also supports flexibility of heterogeneous technologies and spectrum usage. These capabilities of CR technology can make it a key driver for the flexible usage of the most suitable and available bands in a seamless, ubiquitous telecommunication environment.

Under the current trends, many researchers from academia and industry are studying dynamic spectrum management issues not only for technology development but also for regulation and policy reform. In [1], a feasibility study of secondary spectrum uses within unused TV bands was presented, and a new networking paradigm with DSA and CR networks was suggested in [2]. In [3] and [4], regulatory and policy issues of emerging technologies for spectrum management were discussed, and DSA-based spectrum trading was addressed in [5] and [6]. However, except for the research on the technology itself, there has been little discussion or analysis of the market or industry, or of the proper interplay between technology, market, and policy required to succeed in the commercialization of dynamic spectrum management technology.

When innovation and technology development occur in a given industry, potential consumers are difficult to find

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1 The Radio Communication Assembly 2003 adopted Recommendation ITU-R M.1645 on the “Framework and overall objectives for the future development of IMT-2000 and systems beyond IMT-2000”. Recommendation ITU-R M.1768 suggests a methodology for spectrum requirement estimation based on M.1645. The empirical results are presented in Recommendation ITU-R M.2078. With the higher market setting, the total spectrum requirement for the IMT2000 and evolution of IMT2000 systems is expected to be 840 MHz in the year 2010, 1300 MHz in the year 2015, and 1720 MHz in the year 2020. With the lower market setting, total spectrum requirement is expected to be 760, 1300, and 1280 MHz, respectively.

2 ITU only included pre-IMT systems and IMT-2000 and its enhancements and IMT-advanced systems.
Immediately in the new market. Therefore, business activities should be conducted efficiently to find and vitalize the new market so that consumers can easily trade in the market [7]. That is, profitable business models and adequate industry structure will determine the diffusion of the DSA technology.

We study the implementation feasibility of CR research and development in the current circumstances, and we derive several CR-based DSA scenarios that are based on the technology feasibility, application scope, spectrum policy, and stakeholders’ roles. To be more specific, we consider the wireless industry and spectrum policy in Korea. Based on the scenario analysis, we discuss the issues that may arise in DSA with CR such as technical implementation, regulatory framework, and stakeholders’ positioning issues. After those in-depth discussions, we examine strategic approaches for service providers, manufacturers, and policy makers for the successful commercialization of CR with dynamic spectrum management. Finally, we address policy implications.

II. COGNITIVE RADIO VISIONS

In the overall perspective, benefits from the introduction of CR technology appear in several areas. First, for resource management, the efficiency of usage of limited spectrum can be maximized. Second, for the industry, a mobile market can be revitalized by the advent of a new equipment market and a high level of competition with low entry barriers. Third, the operators can create new revenue streams from secondary trading as well as improve utilization of the spectrum resource that they already own. Finally, consumers can be provided with a personalized and optimized mobile service at low cost. Therefore, there are currently many R&D projects related to CR technology worldwide; the main representative examples are WINNER, E2R, PULSERSII, CORVUS, DIMSUMnet, and DRIVE/OverDRIVE [2, 8, 9]. Standardization activities such as IEEE P1900 and IEEE 802.22 are now underway [10, 11]. The results of CR projects can be applied to the various technologies and lead to innovative change with more converged and complex mobile systems. Figure 1 shows the relation between CR and other technologies.

Currently, there are some efforts to find an applicable usage with CR technology in Korea. Applications should be developed for the military and public safety areas and also for commercialized mobile services to vitalize the CR-based dynamic spectrum market. Given that IEEE 802.22 working on the unused VHF/UFH (50–862 MHz) band is based on the IEEE 802.16 (WiMAX standard), WiBro3 may also be used to apply CR technology. Moreover, some parts of the 2.3 GHz WiBro service band are now vacant because one of the WiBro service providers, Hanaro Telecom, returned its assigned spectrum band. Therefore, this vacant band could be utilized as an unlicensed band. Because the target market of the IEEE 802.22 standard has lower population densities than that targeted by the WiBro service, a combination of the two standards using CR could enable several applications.

In addition, a wireless home network service using a collaboration of CR and ultrawide band technology is also considered as one of the options. Spectrum usage research has revealed many unused spectrum bands over 3.1 GHz available for ultrawide band; hence, CR with ultrawide band networks could be used for wideband transmission services. Furthermore, CR is being considered as a DTV wireless return channel to accommodate the increasing demand for digital television uplink services and to allow interactive television and Internet multimedia services to be offered. A related standard is the DVB-Return Channel for Terrestrial Systems (DVB-RCT) [12]. Along with those CR-related technologies, user authentication and information protection also have a key relation with CR technology since those technologies are commonly needed in the heterogeneous network especially in the spectrum common CR network.

On the other hand, discussions about regulation and policy were started in the ITU’s WRC-07, which is considering regulatory measures to enable the introduction of software defined radio and CR systems. In contrast to the technology evolution, research on regulation and policy is still in its beginning stages.

III. COGNITIVE RADIO SCENARIOS

A. Cognitive radio scenario outline

The aim of this work is to classify available scenarios, services, and performance metrics as a framework for analyzing the feasibility of possible CR-based DSA scenarios. The scenarios are differentiated on the basis of technical characteristics, such as available spectrum band and network configuration, and methods of spectrum management policy.
that are market-based trading, opportunistic sharing, or an unlicensed regime. Based on this differentiation, the scenarios are divided into two groups: a nomadic scenario and a mobile scenario according to the technical characteristics of the network configurations. The network configurations and methods for spectrum sharing refer to the current ongoing CR-related projects [8, 9, 16, 17, 18].

B. Scenario classification by sharing methods

CR feasible scenarios can be distinguished by their spectrum sharing method. According to the existence of a primary user, scenarios are classified into two groups: secondary sharing and unlicensed sharing. In secondary sharing, a secondary CR user can share spectrum with the primary spectrum user either by contract or by a ‘listen-before-talk’ opportunistic sharing. In unlicensed sharing use, there is no primary licensed user, and so all CR users have the same right to access a specific unlicensed band and they share spectrum in an opportunistic manner.

In secondary sharing by contracts, secondary CR users take over the spectrum access through spectrum trading or spectrum leasing. Therefore, CR users acquire a legal right and a stable time to use the spectrum. However, in the opportunistic sharing use case, the CR network user should use the spectrum band in an opportunistic manner without causing interference to the primary users. CR users can therefore configure either an infrastructure that constructs a secondary network with their own access point or an infrastructure-free (called infra-less) peer-to-peer network. Overcoming harmful interference caused by a secondary user is the key issue in this case.

IEEE 802.11 devices operate with listen-before-talk spectrum access, change the operation frequencies dynamically, and control their transmission power to minimize interference problems. Spectrum sensing in real time is also critical. In these secondary sharing scenarios, the spectrum management policy should allow secondary use by spectrum lease, secondary trading, or opportunistic sharing.

On the other hand, in unlicensed use, there is no licensee and so any network can use the particular unlicensed band equally. Therefore, the policy maker should establish fair usage rules and etiquette to allow efficient spectrum sharing in an unlicensed band. In this case, infra-less networks such as P2P and relay networks are suitable.

C. Scenario classification by applications

The CR scenario can be classified into two parts: a nomadic scenario and a mobile scenario. Tables I and II show these scenarios. In the nomadic scenario, the secondary–secondary opportunistic sharing method in an unlicensed band is more likely to be preferred than the primary–secondary opportunistic sharing method. In most cases, an application in a nomadic service prefers a high data rate to mobility. That is, a business model can be created for multimedia service over small coverage areas. Figure 2 illustrates nomadic CR scenarios.

In case S1, incumbents initially using the ISM band could expand their coverage using CR in the UHF TV band so that a service could be extended from short distances to long distances. To use cognitive multi-channels in case S2, DSA technology is indispensable. Service providers can support various QoS services using additional unlicensed channels by CR sensing. For example, a shadowed zone or a hotspot area that is short of channels can be assigned more channel bandwidth by unlicensed CR channels.
TABLE I Nomadic cognitive radio scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Spectrum Band</th>
<th>Usage</th>
<th>Advantages</th>
<th>Issues</th>
<th>Similar scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Unlicensed band, UHF TV band</td>
<td>Home, Campus, WRAN</td>
<td>Coverage expansion, Seamless connection, Low cost</td>
<td>Interference, TPC, Spectrum mobility, Spectrum sensing</td>
<td>UCoMS</td>
</tr>
<tr>
<td>S2</td>
<td>Unlicensed band</td>
<td>Home, Office, Hot spot</td>
<td>Capacity increase, QoS support</td>
<td>DFS, CCC</td>
<td>Basic ORACLE</td>
</tr>
<tr>
<td>S3</td>
<td>Unlicensed band</td>
<td>Office, WPAN</td>
<td>Infra-less/Low cost</td>
<td>Ts-Rx handshake</td>
<td>Advanced ORACLE</td>
</tr>
<tr>
<td>S4</td>
<td>Unlicensed band</td>
<td>Home, Office, Hot spot</td>
<td>Coverage expansion, Capacity increase</td>
<td>DFS, CCC</td>
<td>-</td>
</tr>
</tbody>
</table>

TABLE II Mobile cognitive radio scenarios

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular</td>
<td>S1: Short coverage with ISM band</td>
<td>S3: Primary-Secondary with UHF TV band</td>
<td>S4: Open shared with FSS band and UHF TV band</td>
</tr>
<tr>
<td>Relay</td>
<td>S5: High data rate service with ISM band</td>
<td>N/A</td>
<td>S6: Large coverage with UHF TV band</td>
</tr>
<tr>
<td>Infra-less</td>
<td>S7: P2P with unlicensed UHF TV band</td>
<td>N/A</td>
<td>S8: P2P with open shared UHF TV band</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S9: Cognitive Radio based dynamic spectrum access with whole band</td>
</tr>
</tbody>
</table>

In contrast to S1 and S2, spectrum users in cases S3 and S4 do not configure their own infrastructure and so investment cost can be reduced and operation management is decentralized. Like S3 and S4, peer-to-peer networks or relay networks using CR scenarios result in easier access to spectrum for a potential operator; thus, the barrier to enter the market for small-scale local operators is lowered. Moreover, new stakeholders could appear through additional relay nodes in the business model. It is also possible to see a synergy effect from cooperation between adjacent operators and P2P users. CR may ultimately allow operators to share spectrum resources in real time in an ad hoc manner. Nonetheless, it is difficult to establish an etiquette and a management policy, and DRM issues could also be an obstacle in P2P environments.

As Table II shows, we can divide CR mobile scenarios into nine usage cases according to the network configuration and the spectrum sharing method. In mobile scenarios 1 and 2, current service providers improve their service quality using CR. In other words, in case S1, incumbents can expand their capacity to provide high data rates using CR in the ISM band and, in case S2, incumbents could expand their coverage using CR in an unused UHF TV band. S2 depends on the spectrum policy allowing the use of an unlicensed UHF TV band.

Since the circumstance that a spectrum auction has already been held for the UHF TV band in a country such as the USA and secondary trading has been introduced in some countries, case S3 would be the most feasible scenario. The spectrum broker’s role is critical in this scenario and it could affect the market structure. In scenario 4, CR is used in an opportunistic way in the FSS terrestrial and UHF TV bands. A solution for the resulting interference is required urgently. In the FSS band, S4 has high uncertainty because each country is in a different position for the sharing of the FSS band with other technologies.

The mobile scenarios 5 to 8 and the nomadic scenarios 1 to 4 are structurally analogous to each other. In this overall perspective about the feasibility of scenarios, it is clear that the dependence of the spectrum management policy is quite high in most scenarios. Finally, case S9 implies full dynamic spectrum access and Figure 3 illustrates this scenario. When S9 is ultimately realized, spectrum access will not be limited or distinguished by different systems and services.
IV. SCENARIOS ANALYSIS

A. DSA Market forecast

The end user’s wants for wireless mobile service are changing in several ways: ambiguity between wired and wireless service, preference for wideband services, importance of security, unlimited video service, easy and convenient interfaces, and simple and easy handheld operation [13]. In response to those changes, CR-based dynamic spectrum use will allow applications that support different qualities of service and that create a business opportunity for small operators. With the change in market structure, dynamic spectrum access technology will promote both vertical disintegration and horizontal integration of the existing wireless telecommunication market; the former creates new business models and the latter requires the handheld flexibility of CR [14]. Some form of Mobile Virtual Network Operator (MVNO) might become a popular business model in the DSA environment, and other open-access networks could emerge.

B. Cognitive Radio scenario analysis

The CR scenarios that we described in the previous section could have disparities between their technology, policy, and business sides in terms of their feasibility and realizable timelines. Successful establishment of each scenario is possible only when the three aspects coincide with each other. Tables III and IV show the results of feasibility analyses and the critical issues to be solved for the three different aspects. The unused UHF TV band and the ISM band are currently considered as the first target bands for CR applications by investigating the derived scenarios timeline.

The nomadic scenarios analysis shows that S2 has the earlier feasible timeline from the three aspects. Because the main purpose of this scenario is to increase capacity and differentiated QoS, service providers that use this scenario should benefit from the enhanced user satisfaction. The reason we expected S2 to mature earlier than S1 is the availability of spectrum for each scenario. Because the DTV transition is planned to finish in 2012 in Korea, unused DTV bands can be available for the CR network after 2012. However, S1 also has a regulation and policy problem to be solved before the scenario is fully defined. First, sufficient unlicensed bands suitable for CR technology must be found and opened to CR users. As well, management policy for the number of allowable access points should be established considering market conditions and technology characteristics.

We expect S3 and S4 to be established later than S1 and S2. Difficulty in the development of a business model for those CR network scenarios is the most important reason, but technology for network self-management and resource distribution are also key requirements in realizing decentralized network scenarios like S3 and S4. Above all, developments related to the business model are the main prerequisites for establishing scenarios successfully. An operations model for small networks based on a local area or group community is one option. Furthermore, a business model for relays is required for S4. When those networks are actively operated and managed with interoperability, service providers can create diversified businesses and end users will have the opportunity to experience a variety of services at low cost. Furthermore, solutions for the security and Digital Rights Management (DRM) issues are required.

On the other hand, the analysis indicates that, although S1, S2, and S3 have fast timelines, they are highly dependent on
spectrum management policies. S4 depends on interference issues and the use of the FSS band as a sharing band. The mobile scenarios 5 to 8 and the nomadic scenarios 1 to 4 are structurally analogous to each other. The final destination of mobile CR is scenario 9, and the full DSA scenario will be possible under a fully supportive spectrum management policy. Moreover, a proper business model is also a key factor in achieving a successful market that makes full use of CR technology. By the evolution of the CR system, the value chain of mobile market can be changed with value creation and migration [15].

<table>
<thead>
<tr>
<th>Technology Analysis</th>
<th>Policy Analysis</th>
<th>Business Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>S3: Capacity expansion considering fairness</td>
<td>S1,S2,S4: Capacity expansion</td>
<td>S2,S3: Low cost, increase quality, profit creation</td>
</tr>
<tr>
<td>S1,S2,S4: Relay &amp; Infrastructure network configuration</td>
<td>S5,S6,S7,S8: Policy for unused UHF TV band</td>
<td>S1,S4: Low cost, Difficulty for reliable service</td>
</tr>
<tr>
<td>S9: Full DSA technology</td>
<td>S9: Full dynamic spectrum management</td>
<td>S5,S6,S7,S8: Various service, new business model, Uncertainty</td>
</tr>
</tbody>
</table>

TABLE IV Analysis for mobile cognitive radio scenarios

V. STRATEGIES AND SPECTRUM POLICY

A. Strategies for service provider

As mentioned in the previous section, the introduction of dynamic spectrum technologies will allow open access networks and MVNOs and, because of the lowered entry barriers, the market will be highly competitive. Therefore, incumbents should make an effort to diversify their business model. Not only should new business models be created to deal with the vertical disintegration but viable service bundling or integration based on CR’s flexibility will also be a promising strategy for operators for horizontal integration. To conform with various segmented markets and satisfy users’ requirements, it is expected that the operators’ networks should cover multiple access technologies. Therefore, a single operator might manage heterogeneous networks to secure new markets through segmentation of subscribers. In other words, in the near future, a certain technology may not guarantee market success, but competition may occur through the applications, mobile products, and price.

At present in the wireless telecommunication industry in Korea, mobile service providers have the dominant market position in the mobile industry value chain. This is because the network and mobile portal industry are integrated so that service providers can also possess dominant power in the handheld and platform distribution markets. Therefore, they are also in charge of the actual distribution networks. However, under the CR-based DSA network, this type of closed distribution structure can no longer exist. Thus, incumbents’ dominant power is threatened by new entrants unless they create a new business model to cope with value migration.

On the other hand, if the secondary spectrum trading market is activated, owning a spectrum band might itself create a benefit through trading unused spectrum in the band. Therefore, accurate estimation of spectrum demand and efficient spectrum distribution policy in the network should be well managed to optimize spectrum utilization.

B. Strategies for manufacturer

CR is expected to give another opportunity to the handheld manufacturer as well as the network operator. The attributes of DSA mean that dependence on the handheld’s flexibility will be dramatically increased. Therefore, a handheld manufacturer could strengthen its market power by developing a multimode terminal that uses CR and reconfigurable technology like Software Defined Radio(SDR); moreover, a device with the flexibility to switch between heterogeneous technologies could give great value to the subscribers.

On the other hand, Internet portal providers’ recent efforts on spectrum acquisition and entering the mobile market imply that leadership in the mobile market could be diversified. Under these circumstances, collaboration between a manufacturer and an Internet portal provider is a possible strategy in the reorganized mobile phone industry, particularly when an open network and standardization of platform are fully realized. It is possible that the structure of the wireless industry will become similar to the structure of the Internet and PC industry. If this occurs, the market power of telecommunication operators could be reduced and mobile terminals would be gradually standardized and generalized. Therefore, adding value in the telecommunication industry may focus more on the platform market providing content services.

C. An aim of spectrum management policy

CR technology offers many potential benefits such as improving spectrum utilization and introducing innovative resource management schemes like DSA. Multiple devices and heterogeneous networks can coexist within a spectrum band through CR sharing applications. All these benefits can only be obtained under the appropriate spectrum management policy. Considering the possible CR scenarios derived in the
previous section, CR networks can be developed under the spectrum management frameworks that we have described: secondary trading, opportunistic sharing, and unlicensed use. Therefore, flexible and dynamic spectrum management policies are required.

**New Role**

To allow the secondary use framework, a new role for government or a third party is required. For example, a new entity, the so-called ‘broker’, can appear in both the primary–secondary framework and the secondary–secondary framework. The primary–secondary framework is possible through the secondary trading and opportunistic sharing methods. First, a broker in the secondary trading method of the primary–secondary framework plays certain roles for the activation of the trading market. The main roles of the broker are:

- negotiating between incumbents and entrants,
- finding optimal trading matches considering interference and spectrum heterogeneity,
- scheduling and controlling priority,
- managing fair trading, and
- increasing total revenue and benefit.

However, the broker might cause high transaction costs, which include government taxes and charges, market operator fees, and broker fees. Therefore, an optimized brokerage mechanism should be established. Because low transaction costs boost the spectrum trading market, spectrum management policy makers should cooperate with the other regulatory authorities to minimize taxes on secondary market trading in spectrum rights. Moreover, anticompetitive behavior of operators should be discouraged by regulatory authorities because, despite the economic benefits of trading unused spectrum through a secondary market, providers might resist for competitive or strategic reasons. Figure 4 shows an expected entity for the broker’s functions in a spectrum trading mechanism. For dynamic spectrum management, the broker should be able to control heterogeneity among different spectrum bands and priority among trading agents.

![Figure 4 Function for Broker in spectrum trading](image)

Now, considering the broker’s role in opportunistic sharing in the primary–secondary framework, the main role of the broker is to control the basic etiquette and avoid conflicts between primary and secondary users and to manage interference. If the primary users reveal their spectrum usage pattern to the broker, the broker can manage total spectrum resource pool and guide secondary users so that they can access spectrum under more stable conditions. Uncertainty and risks of the secondary users can be reduced in this way. However, in this situation, there must be an incentive for the primary users to reveal their usage; this could be a fee for the information usage from the secondary CR user.

Finally, the broker’s role in a secondary–secondary CR network may not be a critical issue because decentralized spectrum management is suitable for this situation. The broker's role is therefore to manage the total usage of the spectrum resource and to mediate conflicts between spectrum users. The efforts of the individual spectrum access users and cooperation among spectrum access users are essential in this case.

**Neutrality**

In the dynamic spectrum environment, current spectrum regulatory authorities must find an appropriate way to deal with flexibility to make room for innovation while protecting users from harmful interference. The technologies of dynamic spectrum use require a more flexible approach not only for spectrum sharing by multiple users but also for technology and service neutrality. In particular, when the CR technology is more evolved and more active, the management method for the spectrum heterogeneity should be more elaborate because spectrum trading and opportunistic sharing will occur not only between spectrum access users providing or using a particular service but also between spectrum access users providing or using different services. That is, spectrum sharing will be expanded over the whole spectrum band. Therefore, the distinction between assignments and allocations would be insignificant and spectrum heterogeneity should be considered to allow trading and opportunistic sharing between different spectrum bands. When technology neutrality and service neutrality are universally applicable, conflicts among classifications of spectrum heterogeneity and value evaluation can be expected. Technology neutrality requires no interference between spectrum users regardless of the different wireless access technologies provided in the neighboring service bands. On the other hand, service neutrality allows service providers to offer any service within the voluntarily allocated spectrum bands.

There are links between neutrality and dynamic spectrum management. CR-based DSA technologies could provide higher levels of diversified services with technology and service neutrality. Flexible Access Common Spectrum (FACS) research has been conducted since 2005 and it has contributed to securing spectrum bands that satisfy technology and service neutrality in Korea.
Figure 5 shows the impacts of spectrum management policies. Smura and Saksela originally identified these links in their research [19] and we added additional links resulting from secondary use with opportunistic techniques and CR characteristics. The secondary spectrum trading market will be more active when CR is adopted. Primary users may be less reluctant to join spectrum trading and leasing because of the diminishing interference effects. Hence, new stakeholders may enter the market because of the lower entry barriers and the value chain will become more dynamic. Eventually, those changes in the industry will cause more competition. Moreover, spectrum utilization will be more efficient and there will be greater diversification of applications and increased quality of services. Although technology and service neutrality give industry many benefits, if operators or manufacturers focus on simple profit seeking, there will not be enough investment in universal and public services. Therefore, policy makers should manage those types of public services separately so as to not decrease end users’ welfare.

VI. SUMMARY

We have discussed the feasibility of dynamic spectrum usage solutions based on CR from the technology, policy, and business viewpoints. We analyzed feasibility by investigating scenarios classified according to several viewpoints. We also derived the impact of spectrum management policies on the wireless telecommunication industry and we found that allowing secondary use of spectrum resource and neutrality policies creates positive effects for the industry.

It is certain that CR technology is the core solution to cope with paradigm changes and it will have a ripple effect on the all area of the wireless communication sector. It is not only for the efficient use of spectrum resource, but also for the new user applications and business models. Furthermore, those effects will cause change of the value chain of wireless market with value creation and migration. Technology and service neutrality and transparency for the spectrum access will help markets cope with the dramatically increasing change rate of technology and the market environment. The process of spectrum allocation for specific services and assignment to particular service providers might become unnecessary in the future convergence era.

Moreover, because of emerging technologies like CR, the introduction of flexible spectrum management policies will be unavoidable in the long run. However, new spectrum assignment frameworks such as secondary spectrum trading and opportunistic sharing are still in the discussion stage. When the new entity for the spectrum management is required, its functions and relations with stakeholders should be clarified. Therefore, the proper interplay between technology, policy, and market should be pursued in order to successfully commercialize dynamic spectrum management technology.

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