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International Spectrum Workshop

Conference report

Workshop organised in cooperation with Silicon Flatirons Center | University of Colorado Law School

University Paris-Dauphine, 28 June 2017

RESEARCH

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International Spectrum Workshop

Workshop organised by the Governance and Regulation Chair in cooperation with Silicon Flatirons Center | University of Colorado Law School
28 June 2017

On June 28, 2017, the Silicon Flatirons Center at the University of Colorado Boulder and the Governance and Regulation Chair at the University Paris-Dauphine hosted an International Spectrum Workshop in the historic Raymond Aron conference room at Paris-Dauphine. The goal of the invitation-only roundtable was to bring together leading experts from different fields and different geographic regions to map the changing landscape in the regulation of radio operation.

This workshop report describes the discussions and compiles the research questions raised during the workshop. It is not a consensus document. Its aim is to provide an event summary and also to reflect the diverse views of the roundtable participants. Any opinions or recommendations expressed in this workshop summary are those of the authors and the participants and do not necessarily reflect the views of the participants' institutions.

Introduction

Wireless devices and services are essential to modern society. They enable a host of economic, cultural, and scientific activities, and are crucial not only to commercial services, but also to national defense and homeland security. Because demand for wireless capacity keeps growing in the face of limits on the ability of multiple radio systems to coexist, government plays an inescapable role in creating conditions for spectrum use. At the same time, radio systems are deployed and managed by private and public entities that compete for access to spectrum operating rights, with sometimes blurred boundaries between government and commercial activities.

A guiding premise of the International Spectrum Workshop was to bring together leading experts from different fields and different geographic regions to map the changing landscape in the regulation of radio operation. The areas explored by the workshop participants included allocation, assignment, and management issues of both the licensed and license-exempt approaches. In each of the four sessions, the invited speakers presented their recent work, followed by a group discussion.

I. Spectrum Allocation and Metrics

The first session began with two presentations to spur discussion on how to use risk-informed interference assessment rather than worst-case analysis to make spectrum allocation decisions and to discuss new metrics that reflect spectrum utilization and spectrum-sharing efficiency for equipment compliance. The session was moderated by J. Scott Marcus[1].

First, Pierre de Vries gave a talk on how Quantitative Risk Assessment (QRA) provides a more complete assessment of risk than the use of a worst-case analysis.[2] QRA is a well-established technique in several domains, but it is rather new to spectrum policy. To apply QRA in spectrum, the Federal Communications Commission Technological Advisory Council (FCC TAC) developed a four-step method:[3] The first step is to make an inventory of all significant harmful interference hazard modes. The second is to define a consequence metric to characterize the severity of hazards. The third is to assess the likelihood and consequences of each hazard mode. The fourth and last step is to aggregate the results to inform decision making. Using a case study from the United States, DeVries demonstrated that the use of probability distributions rather than single values for interference parameters provides a more nuanced and comprehensive view of the nature of the hazards, and he discussed the impact of different regulatory choices. Summing up, he argued that spectrum policymakers and managers should incorporate risk-informed decision making into their procedures.

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Next, Peter Anker and Jan Kruys gave a joint presentation on sharing license-exempt spectrum based on multi-dimensional metrics.[4] In his talk, Anker argued that the current European Union compliance standards create barriers to entry and are anti-competitive, as they tend to favor established interests. To address the problem, Kruys described two technology-neutral metrics that could govern spectrum utilization and sharing: a spectrum load metric and a spectrum-sharing efficiency metric. The first measures the amount of energy a system puts into the local spectrum. The second measures how well a system can deal with interference while trying to deliver its service. These two metrics can provide a flexible regulatory regime that is technology-neutral, open to innovation, and leads to efficient use of the license-exempt spectrum. The use of these metrics in the regulatory framework has two major benefits. First, it reduces the administrative burden of keeping regulatory requirements up-to-date regarding new technical developments, and second, it clarifies the relationship between regulatory measures and the use of shared spectrum. The proposed metrics-based approach would lead to simplifications in the definitions of the compliance criteria and the verification of conformity, and would encourage service providers to

1 *See Appendix for participants' titles and organizations*

2 *De Vries, J.P., 2016. "Risk-informed interference assessment: A quantitative basis for spectrum allocation decisions," Telecommunications Policy, http://dx.doi.org/10.1016/j.telpol.2016.12.007*

3 *FCC Technological Advisory Council, Spectrum and Receiver Performance Working Group, 2015, "Basic Principles for Assessing Compatibility of New Spectrum Allocations." Available at: https://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting121015/Principles-White-Paper-Release-1.1.pdf*

4 *Kruys, J., Anker, P., and Schiphorst, R., 2016. «Sharing license-exempt spectrum based on multi-dimensional metrics,» Digital Policy, Regulation and Governance, 18(2), pp. 38 – 52.*

build efficient systems that optimize spectrum utilization for a given application.[5]

The two paper presentations led to a discussion about the difficulties in objectively defining what is "harmful" when one talks about harmful interference. Engineers can determine objective thresholds, factor in probabilities, and even consider several metrics in determining certain limits, but the assessment of whether or not a given interference scenario is indeed harmful is a legal or policy question. In addition, the participants discussed how legacy approaches seem to protect the incumbent and how the proposed objective and quantitative approaches could deal with the incumbent bias better than the existing methodologies. There was agreement that the methods presented by the speakers might help in making better trade-offs between the rights of the incumbent and the rights of the entrants.

Three future research questions emerged in the session. First, how might the movement from the legacy approaches to the new ones take place, i.e., what changes in management might work, and how might the new approaches begin to be systematically operationalized? Second, how might the proposed new methods be applied in cumulative interference scenarios? Third, how might risk assessment tools such as QRA be used in other fields, for example, in data protection and privacy?

5 *A follow-on paper addressing the regulatory perspective will be published in 2018. See, Kruys, J and Anker, P., 2018. "Technology Agnostic Regulatory Criteria for License Exempt Spectrum," Digital Policy, Regulation and Governance, Volume 20, Issue 1. (forthcoming)*

II. Assignment and Management

The second session focused on how auction designs could maximize social values instead of maximizing the revenue from the spectrum sale; in addition, it examined various scenarios in which the management of unlicensed spectrum might be beneficial for users. The session was moderated and commented on by Joëlle Toledano.

First, Gerard Pogorel presented a position paper on how to improve spectrum assignment procedures to meet economic and social policy goals.[6] Pogorel argued that spectrum auctions aiming at maximizing spectrum fees do not stimulate investments and network deployment. Simply put, the idea that the higher the price, the better it is for the economy, is not accurate. The spectrum's value resides in its contribution to the society and the economy. He also mentioned several recent empirical studies, all of which concluded that recent spectrum auctions did not stimulate the expected network investments.[7],[8],[9] The authors of the paper proposed to change the hierarchy of the criteria and to rank deployment objectives first and the spectrum fee second. With that, future spectrum auctions could feature re-balanced spectrum assignment criteria, as well as prioritize the investment plans of operators and put them at the forefront of public choices.

Then, William Webb gave a talk about Managed Unlicensed Spectrum scenarios.[10] Webb offered two examples in which the management of unlicensed bands would be beneficial. The first example is Wi-Fi in densely populated areas. In most Wi-Fi systems, the selection of the frequency is decentralized; each router attempts to find a free channel independent from the other routers. This works well when router density is low, but works poorly when router density is high and the number of channels is insufficient. The solution is some degree of coordination of the management of router frequencies and the device selection of routers in areas with high router density. The second example is wide-area Internet of Things (IoT) solutions. Wide-area IoT solutions typically comprise a base station that needs to transmit between 10% and 50% of the time and could benefit from the use of relatively high power levels. Most of the unlicensed spectrum, however, is configured for short-range devices that communicate infrequently and have limits on transmitted power and duty-cycle, often as low as 1%. Relaxing the duty cycle and transmit power requirements in the case of wide-area IoT solutions would tend, however, to increase interference.[11] In addition, the compromises made in system design to enable low-power devices to communicate over long distances can make wide-area IoT solutions vulnerable to interference. Some solutions may fail entirely if they have no way of feeding the need for a change in parameters due to interference back to the device. A centralized management of the unlicensed spectrum would reassure market players that the wide-area IoT that

6 Pogorel, G., Bohlin, E., 2017. "Spectrum 5.0: Mobile broadband Investment-oriented Assignment Design." See https://www.researchgate.net/project/Spectrum-50-Mobile-broadband-Investment-oriented-Assignment-Design

7 Cambini, C., Garelli, N., 2017, "Spectrum fees and market performance: A quantitative analysis," Telecommunications Policy, 41(5), pp. 355-366.

8 See https://www.gsma.com/spectrum/wp-content/uploads/2017/02/Effective-Spectrum-Pricing-Full-Web.pdf

9 Koutroumpis, P. and Cave, M., 2017, "Auction Design and Auction Outcomes." Available at: https://ssrn.com/abstract=2958745.

10 Webb, W., 2017. «Managed Wifi», Availble at: https://siliconflatirons.org/wp-content/uploads/2017/05/Managed-Unlicensed-Spectrum.pdf

11 CEPT's decision to open the unused "public safety" allocations at 870 MHz to unlicensed devices explored this issue and proposed a new device category – a "network relay point." These devices could use higher power and higher duty cycle in a license-exempt band as long as they are either licensed or registered, limited in number, and not operated by the general public. See http://www.erodocdb.dk/docs/doc98/official/pdf/ECCRep200.pdf

they deploy is future proof, and that they will not need to go back and take out all the sensors due to interference issues a few years from now. Both examples support the view that there are specific areas in which the management of unlicensed bands would be desirable, and that there are other areas where it would not be worthwhile.

Relaxing the duty cycle and transmit power requirements in the case of wide-area IoT solutions would tend, however, to increase interference.

Next, Joëlle Toledano commented on the benefits of spectrum auctions in light of the known problems with beauty contests. Spectrum auctions are objective and transparent. Technical and financial information asymmetry and the risk of legal challenges can also be better addressed with auctions than with beauty contests. Furthermore, auction designs may well consider policy objectives. Quoting from a recent research paper,[12] she mentioned three examples where the auction design can be adapted to meet specific policy, efficiency, and equity objectives: first, when spectrum caps or set-asides for new entrants are created to combat the exercise of market power downstream; second, when the license conditions include obligations to provide coverage in non-commercial areas; and third, when the promises of the fulfillment of social objectives are weighted in the determination of winning bids.

Thereafter, a discussion followed about the allocation efficiency of spectrum auctions. Martin Cave commented that spectrum rights are issued by governments, which have an interest in maximizing rents. High spectrum auction prices suggest that governments sometimes promote high prices, to the detriment of the sector and the general public. The group formed a consensus that when regulatory responsibility is assigned to the government, and not to an independent regulatory authority, it is not a good idea to involve the ministry of finance in the spectrum auction process, as its interest would be in the short-term maximization of payments to the public treasury.

The digital economy has a broader social impact, such as informed democracy, access, and inclusion of an educated citizenry. If these externalities could be measured better, and assigned an accurate value, problems with the auction process could perhaps be fixed by, for example, giving bidding credits to participants in the auction if the service they are prepared to provide exhibits the external benefits.

Eric Brousseau pointed out that it is important to analyze the allocation mechanism, but it is also important to investigate what is being allocated—licenses or tradable rights. Allocating tradable rights, instead of allocating licenses, might in principle resolve many of the externalities that arise in the management of spectrum. This led to an inconclusive discussion as to why spectrum rights, which are legally tradable in all EU member states, are in fact rarely traded by mobile operators except in cases of bankruptcy or acquisition.

Two future research questions emerged in the second session. First, how can future assignment procedures deal with the social objectives, and how can the social goals (or other externalities) be reintegrated into the assignment procedure? Second, why are secondary markets in spectrum licenses in the EU so illiquid, and how could liquidity be induced (e.g. by changing the terms of the tradable rights)?

12 *Cave, M., Nicholls, R., 2017. "The use of spectrum auctions to attain multiple objectives: Policy implications," Telecommunications Policy, Volume 41(5–6), pp. 367-378.*

III. Next-Generation Spectrum Enforcement

The third session of the roundtable, moderated by Christopher Yoo, began with a presentation by Pierre de Vries, on behalf of Dale Hatfield, of the FCC TAC's study regarding the development of the next generation systems architecture for radio spectrum interference resolution.[13] De Vries pointed out that traditional radio communications systems are different from today's solutions in many respects. First, they utilized high power transmitters with high antenna sites that produced signals that were easy to detect and locate using relatively unsophisticated, manually operated spectrum monitoring and direction-finding systems. Second, traditional radio communications systems typically occupied a single or limited number of (often) narrowband channels and used a limited number of modulation methods. Third, they transmitted unique identifying information, for example, call letters and associated information content itself in the clear (or in a form that was otherwise easily decipherable). Fourth, their communication channels were typically noise limited rather than interference limited. Moreover, in the past, unapproved transmitting devices designed for deliberate jamming were not widely available, and end-user devices also had very limited processing, storage, and display capabilities and had no means of ascertaining their location.

Today's systems use sophisticated modulation and signal compression techniques. These techniques are changing the exposure of the radio communications systems to both intentional and unintentional interference. Also, existing and future resources for detecting, classifying/identifying, locating, reporting, mitigating, and remediating interference are and will continue to be scattered across multiple entities, both public and private. As a result, next generation interference resolution systems should be automated, resulting in not only rapid interference resolution, but also cost reduction. Budgetary constraints on public entities and cost minimization pressures on commercial entities also justify the need for automation and the avoidance of the unnecessary duplication of facilities and functions. Summing up, De Vries asked the group to discuss the merits of the paper and to make recommendations on new interference resolution architectures, both technical and institutional.

As the commenter, Didier Chauveau offered his views on the paper and gave his perspective on the contemporary challenges in radio spectrum interference resolution in France. He remarked that establishing a common framework for enforcement is very difficult when operating in a completely deregulated market due to the growing forms of spectrum usage by an expanding number of players. Chauveau also confirmed the difficulties due to budget constraints; his group is under constant cost pressure, although the number of tasks is increasing due to the changes in technology.

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Next, a discussion followed about the differences between enforcement in Europe and the United States. Scott Marcus highlighted the problem by contending that cross-border interference is of a different magnitude in Europe than it is in North America. He also mentioned that the various spectrum regulators in all 28 member states generally do

13 *FCC Technological Advisory Council - Spectrum and Receiver Performance Working Group, 2016, «A Study to Develop the Next Generation Systems Architecture for Radio Spectrum Interference Resolution,» Available at: https://transition.fcc.gov/oet/tac/tacdocs/reports/2016/A-Study-to-Develop-a-Next-Generation-System-Architecture-V1.0.pdf*

not perform continuous active monitoring; the monitoring is either episodic or driven by complaints. Bob Horvitz added that if smart devices are employed to support enforcement, the geographical and political differences must be kept in mind. What might work in one part of the world might not work in other countries or might have different political consequences.

This led to a discussion about crowdsourcing. William Webb pointed out that smart devices will have an important role in the future in managing interference. William brought up the example of smart TVs, and more generically, smart devices. These can be aware of something that might look like interference. They might not be able to identify exactly what the source of the interference was, but they could be aware that there seemed to be a substantial amount of signal blocking. Such information could be used to manage the interference issues if it was collected in real time and placed into a database.

There were questions about whether a central database is a good solution to aid enforcement. Horvitz pointed out that if we required all devices to depend on a geodatabase-lookup solution, the development of self-managing cognitive radios would never happen. Chauveau added that it is important to establish confidence regarding the database, the source and the quality of information, and to address privacy concerns. Yoo remarked that without a real enforcement mechanism, a voluntary compliance information-servicing regime would not be effective.

The group agreed that additional research is needed to aid the creation of a conceptual technical and institutional architecture for radio spectrum interference resolution. There was also agreement that a comprehensive and publicly available database of enforcement actions and better information exchange between stakeholders would benefit research and policy making in this area.

IV. Standards and Public Policy Goals

The fourth and last session, moderated by Howard Shelanski, started with a presentation by Phil Weiser to spur discussion on how to address public policy goals, such as disability access, lawful intercept, or cybersecurity through the standard-setting process. Weiser presented Dale Hatfield's paper, entitled "Addressing Public Policy Goals in the Standards Setting Process: The Case of 5G Wireless Standards." Hatfield participated in the session remotely from Colorado.[14]

Weiser started his talk by emphasizing that in an increasingly globalized and technologically dynamic sector, it is challenging for national regulatory authorities to keep up with and influence the standards-setting process. The architecture for 5G networks, for example, is being developed by a vast range of technical standards-setting organizations (SSOs) across the world. In the process of developing the standards that enable 5G, these bodies will address a range of important questions, such as the degree to which these networks are open or closed, and they will make design choices that affect certain public policy goals. The stakeholders that participate in the standards-setting process have differing incentives that might not include the advancement of public policy goals. As a result, by the time the standards are set, it might be too late for policymakers to raise basic policy questions, for example: *"How do we ensure that 5G enabled devices work for public safety?,"* or *"How do we address cyber security concerns?"*

If we are living in a world where international standards are important, and if those standards then have a substantial influence on policy, should we worry about how those bodies operate? Can we expect SSOs to follow due process norms, providing transparency, notice, and an opportunity to be heard? In his paper, Hatfield recommended that the appropriate national agencies should reassess how they relate to SSOs and take steps to ensure that public policy goals and the views of all stakeholders are addressed in the international standards-setting process.[15]

Next, Martin Cave offered his views on the paper and contributed related thoughts on the topic. He agreed that the way in which standards have been set has changed enormously over the past two decades. Twenty years ago, standards making was largely a government-controlled activity, but today's standards are set by both traditional SSOs and by coalitions of non-government appointed bodies. The task of understanding the way in which standards-making processes work is rather complex. Cave commented that it is quite reasonable to raise the alarm and to argue for transparency; however, it might be premature to assume that the processes will not resolve themselves.

A dialogue followed about the role of the International Telecommunication Union (ITU) and its claim for its legitimacy and primacy in standards making. Eric Brousseau commented that the ITU has been failing in both legitimacy and agility. For years, it was dominated by governments and state monopolies, and then, it failed to manage policy aimed at establishing a level playing field and managing entry by innovators. That is why it has been bypassed by other emerging organizations in the management of standards setting or internet governance.

14 Hatfield, D., 2017. «Addressing Public Policy Goals in the Standards Setting Process: The Case of 5G Wireless Standards». Available at: https://siliconflatirons.org/wp-content/uploads/2017/05/Addressing-Public-Policy-Goals-in-SSOs-DNH-052217-gmp-ajv.pdf

15 The proposal is made for the US context but the paper's recommendation is also applicable for national regulatory authorities in other countries.

Brousseau's comments led to a lively discussion about the role of the ITU. The conversation echoed the prevailing view that the involvement of the ITU is probably not going to be of great help in today's standards-making processes. This view, however, did not reach a consensus among the participants. Some opined that while the ITU may not be the right place to advance standardization in 5G, it still delivers real value in certain areas, for example, in the satellite domain.

There were several comments and some debate about how the views of all the interested stakeholders (industry, government, academia, and civil society) can be represented at each stage of the standards-development process. Horvitz has very little hope that civil society can manage any change in the standards-setting world simply because of the cost and scope of involvement that is required. Alberto Di Felice opined that if standardization happens correctly, it should take policy and public policy goals into consideration, and there is no need for civil society groups to be involved. If a standard does not comply with the rules and regulations mandated by law, it should simply not be on the market. Michelle Farquhar added that competition policies are important with respect to standards because smaller players and new entrants do not typically have the funding to participate in the large standards bodies; therefore, they must rely on their interests being propelled by equipment makers and larger operators, which do not necessarily have the same goals or interests.

Two promising future research questions emerged during the last session. First, how could the standards-setting bodies themselves be advised and incented to consider what strategies can ensure that the relevant standards facilitate the best technical performance, enable economic growth, and address core social policy goals? Second, it would also be interesting to perform an ex-post, comparative institutional analysis of what kind of entity or entities in various domains were able to create standards and made decisions that also reflected public policy goals.[16]

16 *The Internet protocol suite, for example.*

Concluding Remarks and Acknowledgements

Interdisciplinary collaboration is key to addressing the open challenges in wireless spectrum management. The conversations in the workshop sessions and during the breaks echoed the prevailing view that international dialogue and comparative institutional analysis on spectrum policy is important and that the international roundtable fulfilled its objective in advancing scientific knowledge by enabling leading experts from different fields and different geographic regions to review and discuss the changing landscape in the regulation of radio operation.

The workshop was co-organized by the Silicon Flatirons Center at the University of Colorado Boulder and the Governance and Regulation Chair at the University Paris-Dauphine. It was supported by the Center for Technology, Innovation and Competition at the University of Pennsylvania Law School, Hogan Lovells, and the GSM Association.

Appendix A: Workshop Participants

- Peter Anker, Senior Policy Advisor, Frequency Management, Ministry of Economic Affairs, The Netherlands
- Jakob Blaavand, Senior Consultant, Smith Institute, UK
- Wladimir Bocquet, Director of Regulatory Affairs, Spectrum Management and Policy, Eutelsat, France
- Eric Brousseau, Scientific Director, Governance and Regulation Chair, Université Paris-Dauphine, France
- Martin Cave, Visiting Professor, Imperial College Business School, UK
- Didier Chauveau, Deputy Director, Spectrum Planning and International Affairs, Agence Nationale des Fréquences, France
- Pierre de Vries, Spectrum Initiative Co-director and Executive Fellow, Silicon Flatirons, University of Colorado Boulder, USA
- Mérouane Debbah, Director, Mathematical and Algorithmic Sciences Lab, Huawei Technologies, France
- Alberto Di Felice, Senior Analyst, Government Affairs, Qualcomm, Belgium
- Philippe Distler, Member of the Board, ARCEP (France's Electronic Communications and Postal Regulatory Authority), France
- Morten Falch, Associate Professor, Aalborg University, Denmark
- Michele Farquhar, Partner, Hogan Lovells, USA
- Catherine Gabay, Deputy Director, Spectrum Monitoring, Agence Nationale des Fréquences (ANFR), France
- Dale Hatfield, Spectrum Policy Initiative Co-Director and Executive Fellow, Silicon Flatirons; Adjunct Professor, University of Colorado Boulder (via Skype for Sessions 3 & 4)
- Robert Horvitz, Associate Manager, Grant Thornton Advisory, Czech Republic
- Jan Kruys, Manager RF Standards and Regulations, Qorvo Utrecht BV, The Netherlands
- J. Scott Marcus, Independent Consultant, Economist, Belgium and Germany
- Winston Maxwell, Partner, Hogan Lovells, France
- Gabor Molnar, Senior Fellow, Silicon Flatirons, University of Colorado Boulder, USA
- Samer Mourad, Principal, Analysys Mason, France
- Stéphane Piot, Partner, Analysys Mason, France
- Gérard Pogorel, Professor of Economics and Management-Emeritus, Telecom ParisTech, France
- Howard Shelanski, Professor of Law, Georgetown University, USA
- Brett Tarnutzer, Head of Spectrum, GSMA, UK
- Joëlle Toledano, Professor of Economics, CentraleSupélec, France
- William Webb, Professor, CSaP, University of Cambridge; Director, Webb Search Consultancy, UK

- Phil Weiser, Executive Director and Founder, Silicon Flatirons; Hatfield Professor of Law, University of Colorado Boulder, USA
- Christopher S. Yoo, John H. Chestnut Professor of Law, Communication, and Computer & Information Science, University of Pennsylvania, USA

Appendix B: Summary List of Research Questions

- How might the movement from the legacy approaches to the new methods and metrics take place, i.e., what changes in management might work, and how might the new approaches begin to be systematically operationalized?
- How might the proposed new methods and metrics be applied in cumulative interference scenarios?
- How might risk assessment tools such as QRA be used in other fields, for example, in data protection and privacy?
- How can future assignment procedures deal with the social objectives, and how can the social goals (or other externalities) be reintegrated into the assignment procedure?
- Why are secondary markets in spectrum licenses in the EU so illiquid, and how could liquidity be induced (e.g. by changing the terms of the tradable rights)?
- What is the best conceptual technical and institutional architecture for radio spectrum interference resolution?
- How to create a comprehensive and publicly available database of enforcement actions?
- How could the standards-setting bodies themselves be advised and incented to consider what strategies can ensure that the relevant standards facilitate the best technical performance, enable economic growth, and address core social policy goals?
- What kind of entity or entities were able to create standards and made decisions in various domains that also reflected public policy goals (comparative, ex-post institutional analysis)?

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