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Responsible Research and Innovation through Gender-Responsive Collaborative Virtual Hubs

Ana Inês Oliveira^{1,2}, Sanaz Nikghadam-Hojjati^{1,2}, Filipa Ferrada^{1,2,3}

¹ Uninova Institute, Centre of Technology and Systems (CTS), Portugal
{aio, sanaznik, [faf](mailto:faf@uninova.pt)}@uninova.pt

² NOVA School of Science and Technology, FCT-NOVA, Caparica, Portugal

³ Sustain.RD center, ESTSetúbal, Instituto Politécnico de Setúbal, Campus do IPS, Setúbal

Abstract. Responsible Research and Innovation (RRI) through science and technology has a great potential to transform the future and advance society in social, environmental, economic, ethical, and legal aspects. Advancing RRI keys, like gender-responsiveness and gender equality, science literacy and science education, public engagement, open access, ethics, governance, is essential for its development. The present exploratory research paper aims to investigate the role of Collaborative Networks (CN) and gender-responsive collaborative virtual hubs in developing RRI actions. To achieve this goal, authors studied, developed, and synthesized several related concepts. The main contribution of this research work is presenting the theoretical concept based on CNs applied to distinct virtual hubs aiming to promote gender responsive innovation.

Keywords: Responsible Research and Innovation, Gender Responsiveness, Hub Entities, Collaborative Hub, Virtual Meta Hub, Collaborative Networks

1. Introduction

In recent years, as a result of the progress in scientific research and innovation (R&I), attention has been paid to leverage legal, ethical, environmental, economic, and social aspects in terms of the relationship between science and society. This trend is conceptualized by the European Commission through with the introduction of the concept of Responsible Research and Innovation (RRI) [1]. In this context, RRI intends to bridge societal values, needs and expectations about R&I with technological innovation through the engagement of public and responsible multi-actors like citizens, researchers, business, policy makers, governmental and non-governmental organizations, between others. More recently, under the Horizon 2020 work programme “Science with and for Society” (SwafS), six keys constitute the RRI practices they are: Ethics, Science Education, Gender Equality, Open Access, Governance and Public Engagement. This paper, focuses on the gender key by proposing an approach that implies that R&I processes are gender responsive, reflecting the encouragement of equal participation and equal and fair distribution of benefits. In this way, this work aims to investigate the role Collaborative Networks (CN) and innovations hubs moved by the following research question: How can CNs contribute to gender responsive and inclusive innovation? The proposed work, is an exploratory

work that settles on establishing a sustainable and resilient approach on collaboration innovation hubs, supported by the contributions from the CN and gender research areas aligned with the knowledge from established innovation hubs.

In this regard, an analysis on collaboration and gender responsiveness concepts in research and innovation activities and systems is performed followed by the proposal of a theoretical model addressing collaborative virtual hubs.

2. Background

Research and Innovation. Research and Innovation (R&I) is a vital lever to ensure sustainable, scientific, and inclusive development. It boosts the production sector's resilience, improves economic competitiveness, and causes socio-economic transformation. R&I is strongly involved in producing new knowledge, developing innovative products, processes, services, and methodologies for emerging real-life problems, enables higher productivity, efficiency, competitiveness, and prosperity [2]. To consider effects and potential environmental, social, and economic impacts of the R&I activities outcomes, European Union suggested the new term of Responsible Research and Innovation (RRI) which raised from predecessors including Ethical, Legal and Social Aspects studies (ELSA) [3]– [7]. There are various definitions for RRI, however, all of them are prioritizing finding solutions for societal problems and challenges as the main focus of the R&I activities as well as the responsibility to avoid harmful effects, developing innovation-affected communities' engagement, and providing enough knowledge for targeted communities to implement the innovative solutions [8]. One important aspect of RRI is advancing diversity and gender equality in the R&I system [9] that could not be achieved without multi-actor based collaboration in R&I activities which is defined as research involving coordination between the researchers, institutions, organizations, and/or communities [10]. In this context, Collaborative Networks (CN) can play an important role in RRI, acting as key enabler to collaborative work among such heterogeneous stakeholders, by providing common infrastructure, governance principles, business processes and integrated services, fostering inclusiveness and sustainability in the R&I actions.

Gender Responsiveness Research and Innovation. According to United Nations Development Programme (UNDP), Gender Responsiveness (GRs) refers to the activities and outcomes that reflect optimized perception and understanding of gender roles and gender inequalities and activities aimed to encourage equal and inclusive participation and equal and fair distribution of benefits [11]. GRs by accepting biological difference aim to change mindsets and attitude by creating and fostering an environment in which everyone gets equal opportunities and benefits. Lack of Gender Responsive (GR) in research, innovation, product and service production, process, methodology which mostly is result of “default male bias” currently strongly impacts women life and impose negative consequences on society. For example, female drivers which involve in car crashes have a 47% greater chance of serious injury than their male counterparts, and a 71% higher chance of a moderate injury because car safety features are designed for men [12] and most of crash-test dummies are designed based

on the “average” male [13]. We can find a lot of other facts related to “default male bias” and gender irresponsiveness in different aspect of our lives such as medical and health care [14], medicine production [15], dealing with traumas [16], research funding [17], digitalization [18], decision making [19], research and innovation activities [20]. “Default male bias” facts shows that our world was not built for women and still has a huge gap to be adequate for them. According to World Bank reports, closing gender gaps can enhance economic productivity and improve development outcomes [21]. To close this gap, Gender-Responsive Research, and Innovation (GR R&I) is vital, since gender responsive research and innovation implies both inclusion of women and men in the innovation process and that the innovation content caters to the needs of both women and men with their interesting diversities in e.g., race, religion, (dis) ability, age. GR R&I have the potential to save lives, resources, and time [22]. Also, Gender Equality (GE, referring to gender-equal participation and representation in R&I) is integral to innovation, and in most R&I fields, improving GE is the key element for achieving technological innovation and innovative sustainable solutions, and its socio-economic ramifications [23].

Hub Entities. Collaboration is increasingly recognized to be important for research and innovation [24] and “Hub Entities” which are community-based, non-profit corporations with offices in a determined geographical location [25] which are responsible to achieve certain goals, could contribute to R&I capacity and productivity by focusing on the collaboration and coordination between autonomous but linked research and innovation ecosystem’s stakeholders. Hub entities are applying hub organizational structure, which is not a hierarchically controlled one, but neither is it a pure network structure in which all control is delegated to the nodes. A hub could be defined as a “modified network” in which a significant amount of the power and decision making are distributed to the teams [26]– [28]. They are different from those organizational models that provide business support without a traditional incubator. Hubs have strong contribution and participation in the innovation ecosystem by combining structured organizational models with incubators support programmes [29]. While a precise definition of hubs remains elusive, we can note that they are more than just a shared workspace, and they can be distinguished from accelerators and incubators, and Labs. They furthermore have diverse origins and can vary significantly in their focuses, for example they may target technology, innovation, research, science, business, or entrepreneurship. Some of Hubs are founded by different sectors such academic institution, civil society actors, private sectors, government, or a combination of all of them. They gain their funding from a variety of resources and operate using diverse business modes [30], [31]. The most common hubs based on their focuses area are innovation hubs, research hub, collaboration hub, learning hub.

Innovation Hub: It refers to an area with two main characteristics: i) innovative activities which predominates within the region in compared with neighboring regions; ii) a strong linkages and knowledge flow via the main region into neighboring region. The idea and principles of Innovation hubs comes from trade, financial and transportation hubs [32]. This type of hubs is central point for the innovation communities’ activities within these areas of focus. They are built on the top of

innovations communities' main stakeholders' labs, offices and mainly focus on innovative products, services, and training programmes development in a specific area of their innovation community [33]. They play as the backbone of innovation ecosystem and community.

Research Hub: This type of hubs' mission is to accelerate the pace of scientific research. They are mostly a technology enabled agent, which bring together academic, industrial, and research and innovation sectors stakeholders to develop new scientific and innovative solutions for specific issues in their targeted communities. Research Hubs by brining valuable expertise and experience together to conduct research on subjects that are important for the local, national, and international communities[34], [35].

Collaboration Hub: It refers to a type of physical or virtual workspace which designed to promote collaboration, communication, interaction, community building teamwork, and productivity. It includes plenty of flexible physical and virtual activity-based work environment for knowledge sharing, collaborating, socializing, brainstorming, meetings, matchmaking, and networking.

Learning Hub: It refers to a technology-rich physical or virtual (or both) environment that provide a variety of opportunities (formal, informal, long term, short term, etc.) for learners to come together with peers, educators, and other stakeholders and have access to the relevant knowledge, guidance from educators and peers, and develop new opportunities [36].

Digital Innovation Hubs: Also, known as DIHs, is a concept formally launched by the European Commission (EC) and defined as an entity which is helping "...companies in the region become more competitive by improving their business/production processes as well as products (and services) by means of digital technology." [37] They are considered as actors or initiatives that support digitalization and the development of the surrounding innovation ecosystem[38].

This paper addresses these topics by proposing a model supported by CNs, Gender Responsive principles and innovation hubs, as described below.

3. Gender-Responsive Collaborative Virtual Hubs

One step towards a gender-responsive research and innovation ecosystem to the co-developing of knowledge and innovation, is aiming a suitable environment where concrete models, methodologies, and tools for advancing gender-responsive, human-centered, and inclusive can be considered. In this line, areas such as Collaborative Networks, Gender-Responsive, and Research and Innovation Hubs are taken into consideration as the foundation for a gender-responsive collaborative virtual hub, as illustrated in Fig. 1.

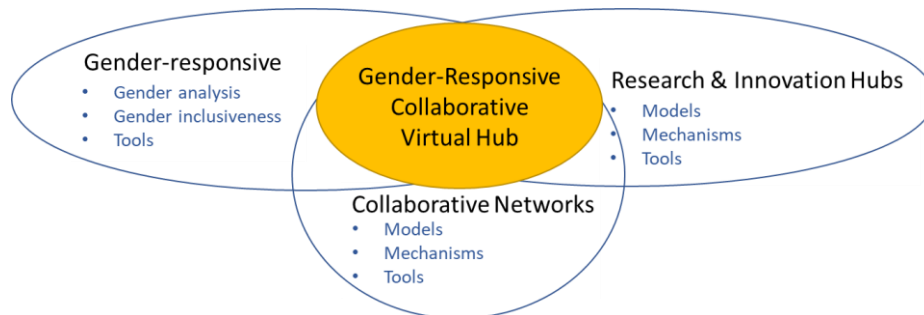


Fig. 1 – Key Areas for Gender-Responsive Collaborative Virtual Hub

In this regard, it becomes appropriated a baseline aligned with the concepts provided by Collaborative Networks (CN) scientific discipline [39]. As such, these can have different typologies and be classified into two major groups: the long-term strategic networks and the goal-oriented networks [40].

On this specific context, for giving the required support for gender-responsive collaboration, it is envisaged the conception of a long-term alliance for the provision of the necessary supporting environment that encapsulates the governing of the different types of supporting entities that must collaborate to support the creation of innovation local living-hubs. This type of collaboration is called Virtual Meta Hub (VMH) and includes a catalog comprising the tools and the methods that can be used to instantiate Virtual Local Hubs (VLH) that are gender responsive compliant. For the creation of a new Virtual Local Hub, two situations can occur: to adapt an existing hub with these virtualization methodologies and tools, or the creation of a new hub that is compliant from the beginning with such methodologies and tools.

During the creation of such VMH, relevant stakeholders shall consider the necessary environment in which a set of models, mechanisms and tools shall be made available and prepared to be updated according to new generated knowledge.

In its turn, the VLHs are goal-oriented networks that involves different types of supporting entities in a defined region, that must collaborate to provide the required support for the promotion of co-creation and/or co-development teams that are gender responsive, making the local innovation ecosystem actors more prepared in the scope of real-life action research.

For the creation of a VLHs, the catalogue of the VMH can be adapted according to the exactly local requirements. For such instantiation, some context-awareness guidelines must exist, enabling an AI-based suggestion system to provide the most suitable environment for a specific VLH being instantiated.

Moreover, as way to enrich the entire process, and that all VLHs can benefit the most from the VMH according to its context, the catalogue included in the VMH, should be a self-organized catalogue that can be dynamically updated according to the feedback provided by the existing VLHs.

Additionally, all teams being created promoting gender responsive innovation are dynamic virtual organizations involved in the co-creation and co-development of innovation in the context of their hubs, called co-Creation Innovation Teams (co-CIT).

Fig. 2 illustrates the gender-responsive collaborative approach that includes the three different types of networks (Virtual Meta Hub, Virtual Local Hub, and co-Creation Innovation Team) together with their bidirectional interaction for suggestion and for updating.

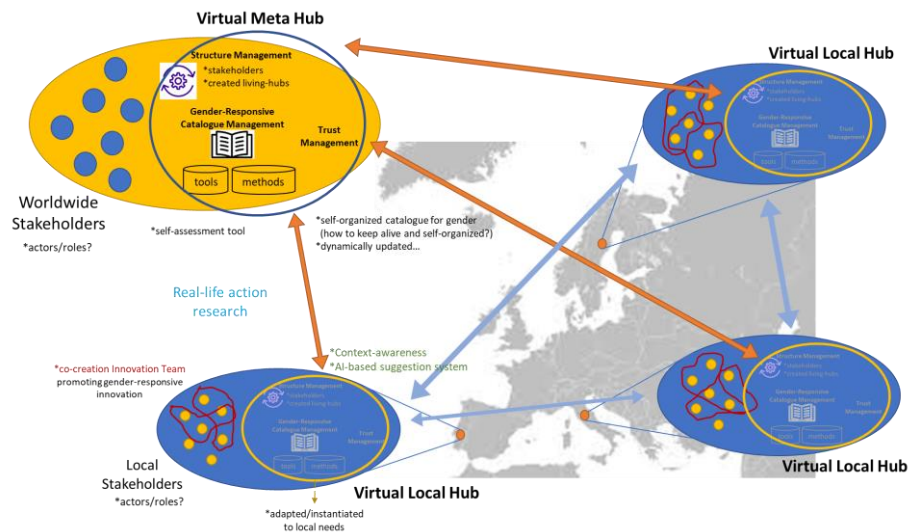


Fig. 2 - Gender-Responsive Collaborative Virtual Hubs Approach

4. Virtual Meta Hub

The main purpose of the Virtual Meta Hub is to promote collaboration between innovation hubs, social sciences researchers and institutions, gender experts at a large scale, aiming to generate new and disruptive plans, methodologies, and tools to promote inclusion and women innovators and develop gender-responsive innovation. In the context of this network, several Virtual Local Hubs might be instantiated aiming at promoting inclusion and gender equal participation in local innovation ecosystems.

A system to support the management of this environment needs to provide services to manage the meta hub stakeholders' profiles and competences, to support gender-responsive innovation management, to facilitate trust building and resilience among all and promote sustainability by means of a suitable incentives and expectations management.

The main strategic goal is to offer gender-responsive best practices, methodologies, and tools (like a catalogue), training and learning services towards their instantiation/uptake in VLHs.

To capture, synthesize and organize the base concepts, principles, and recommended practices of the previous mention networks, it is used the ARCON modeling framework [41]. Through this framework, it is possible to identify the main elements of the

networks, namely the endogenous and exogenous. Considering the focus of this paper, only the *endogenous* elements of the VMH are here considered, once it is the foundation for the entire ecosystem.

Thus, the endogenous elements for the VMH represent essentially the *structural*, *componential*, *functional*, and *behavioral* and all the four elements are classified according to *activity entity*, *passive entity*, *action*, and *concept*, as depicted in Table 1.

Table 1 - Main Endogenous Elements for the Virtual Meta Hub

Structural	<p><u>Active entity</u></p> <ul style="list-style-type: none"> ▪ Actor <ul style="list-style-type: none"> • Primary-entity • Support-entity <p><u>Passive entity</u> N/A</p> <p><u>Action</u> N/A</p>	<p><u>Concept</u></p> <ul style="list-style-type: none"> ▪ Role <ul style="list-style-type: none"> • VMH member <ul style="list-style-type: none"> – Administrator – Adviser – Support provider • Spot member 	<ul style="list-style-type: none"> ▪ Relationship <ul style="list-style-type: none"> • Exchanging • Sharing • Trusting • Socializing ▪ Network <ul style="list-style-type: none"> • VMH-self network • subnetwork
Componential	<p><u>Active entity</u> ---</p> <p><u>Passive entity</u></p> <ul style="list-style-type: none"> ▪ Domain Specific Device <ul style="list-style-type: none"> • Manufacturing Machinery ▪ ICT Resource <ul style="list-style-type: none"> • Hardware • Software <ul style="list-style-type: none"> – Management system – Catalogue 	<ul style="list-style-type: none"> ▪ Human Resources <ul style="list-style-type: none"> • Contact person for VMH • Contact person for a stakeholder ▪ Info/knowledge/asset/resources <ul style="list-style-type: none"> • Profile/competence data <ul style="list-style-type: none"> – Stakeholders profile data – Catalogue • Inheritance information <ul style="list-style-type: none"> Update knowledge from virtual local hubs • Ontologies <ul style="list-style-type: none"> – Common ontologies – Domain ontologies 	<ul style="list-style-type: none"> • Catalogue <ul style="list-style-type: none"> – Resources – Methods – tools • Bag of assets <ul style="list-style-type: none"> – Governance information – Value system – Templates ▪ Network result <ul style="list-style-type: none"> Virtual local hub instantiation <p><u>Action</u> N/A</p> <p><u>Concept</u> N/A</p>

Functional	<p><u>Active entity</u> N/A</p> <p><u>Passive entity</u> N/A</p> <p><u>Action</u></p> <p>▪ Fundamental Processes</p> <ul style="list-style-type: none"> • VMH management process <ul style="list-style-type: none"> – Membership management – Trust management – Value system info management – Support institution management • Participants operational processes <ul style="list-style-type: none"> – Participants Trust assessment – VLH instantiation – VLH creation – VLH registration 	<p>▪ Background Processes</p> <ul style="list-style-type: none"> • VMH management process <ul style="list-style-type: none"> – Creation of new items for catalogue – Catalogue evolution – VLH inheritance management – IP management • Gender-responsive policies creation <p><u>Concept</u></p> <p>▪ Methodology and approach</p> <ul style="list-style-type: none"> • VMH creation and setup <ul style="list-style-type: none"> – Co-creation of VMH – Governance rules – Value system definition – VMH set up 	<ul style="list-style-type: none"> • VMH operation handling <ul style="list-style-type: none"> – Members information quality assurance – Ontology management – Social processes – Governance rules updating – IP Management – Catalogue evolution • Gender-responsive policies updating
Behavioral	<p><u>Active entity</u> N/A</p> <p><u>Passive entity</u> N/A</p> <p><u>Action</u> N/A</p> <p><u>Concept</u></p> <p>▪ Prescriptive behavior</p> <ul style="list-style-type: none"> • Cultural principles <ul style="list-style-type: none"> – Tradition – Culture • Governance principles <ul style="list-style-type: none"> – General principles – Domain specific principles 	<ul style="list-style-type: none"> – Gender-responsive principles • Incentive policies and reward <p>▪ Contract and Agreement</p> <ul style="list-style-type: none"> • VMH adhesion agreement • Agreement amendments <p>▪ Obligatory behavior</p> <ul style="list-style-type: none"> • VMH Bylaws <ul style="list-style-type: none"> – Conflict resolution policies – Membership policy – Contact enforcement – Financial policies • Internal regulations <ul style="list-style-type: none"> – Gende-responsive guidelines – Sanctions principles 	<p>▪ Constraint and condition</p> <ul style="list-style-type: none"> • Confidentiality constraints • Legal constraints • Internal normative constraints • Standard constraints • Physical constraints

To properly model the VMH, it is also important to consider the exogenous elements that are related to the interactions between the network as whole or in relation to others. Therefore, although out of the scope of this paper, dimensions such as *market*, *support*, *societal* and *constituency* should be also defined.

The VMH life cycle follows the ARCON reference model and represents all stages that the VMH passes during its lifetime, namely creation, operation and evolution, and dissolution as depicted in Fig. 3.

The creation of the VMH requires two main steps: (i) initiation and mobilization and (ii) start-up. The VMH is created by a group of founding stakeholders being one of them, the initiator (an organization), assigned to conduct the creation actions. The initiation and mobilization require the setup of a common base infrastructure, the establishment of a base ontology, the establishment of the VMH profile, namely name, legal identity, vision, goal, etc., and the engaging of potential stakeholders (e.g., local hubs) to join the VMH. In its turn, the start-up requires the parametrization of the necessary systems, creation, and population of information repositories.

The operation and evolution of the VMH requires support to stakeholders' profiles and competences management, new stakeholders' registration, gender-responsive innovation catalogue management, collaboration & knowledge creation and sharing, assisting the instantiation of VLH, portfolio management (catalogue with all instantiated VLHs and experiments) and facilitate trust building and resilience among all and promote sustainability by means of a suitable incentives and expectations management.

Finally, the dissolution of the VMH requires a detailed plan to properly deal with the accumulated knowledge, stakeholder's information, gender-responsive catalogues, and other, based on established agreements covering rights and responsibilities.

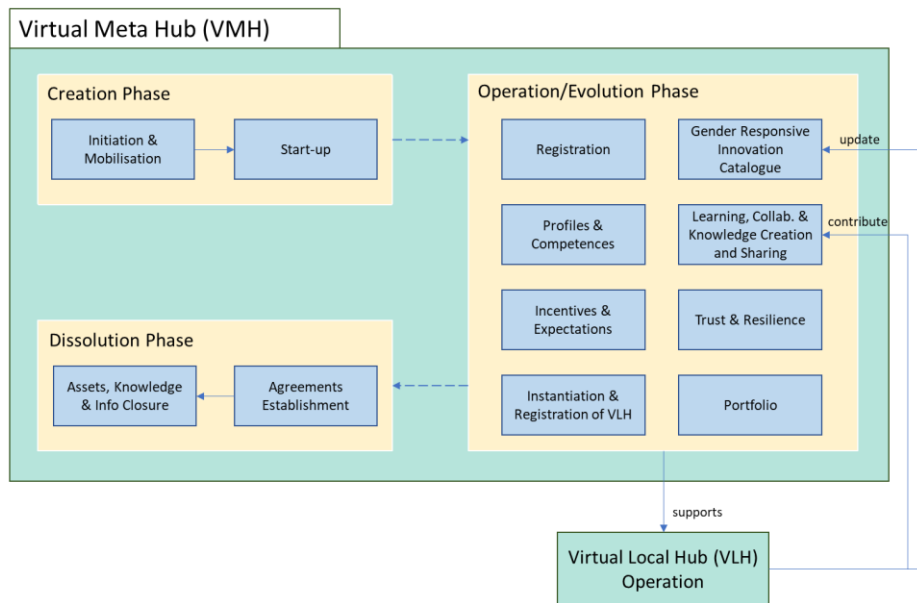


Fig. 3 – Virtual Meta Hub Base Functionality

5. Conclusion and Future Work

Following the trends for leveraging Responsible Research and Innovation, it is important to consider structures that enable collaboration that is gender-responsive and inclusive. For such, this paper presents exploratory research with the aim at investigating how Collaborative Networks can contribute to gender-responsive and inclusive innovation. As the background, several concepts were studied, and synthesized in section 2, namely research and innovation, gender-responsiveness research and innovation, and hub entities, that despite being commonly used, their exact definitions are sometimes unclear. In the following section 3, it was perceived the definition of gender-responsive collaborative virtual hub, that is nurtured by models, methodologies, and tools coming from areas such as Collaborative Networks, Gender-Responsive, and Research and Innovation Hub. Therefore, considering the great contribution from CNs, three different types of networks were defined: the Virtual Meta Hub, the Virtual Local Hub, and the co-Creation Innovation Team. With the main purpose of promoting collaboration between innovation hubs, the focus of section 4 was in the definition of the main endogenous elements of the Virtual Meta Hub following the ARCON reference framework. Also, the description of its main functionalities considering its life cycle was included.

For further developments, besides the definition of the other elements of the VMH and VLH, it is necessary to design and develop models and mechanisms to support the management and governance principles of the learning and collaborative VMH, that includes stakeholders profiling and competence management (namely regarding their R&I competences), competences gap analysis, innovation readiness assessment, and value system alignment, and incentives management. These models should also comprise the instantiation of VLHs where the more appropriate collaboration methods and tools can be selected to support its multi-actor members in the co-creation and co-development of multi-disciplinary processes where new innovative products or services are envisaged by co-creation Innovation Teams. Moreover, models and mechanisms to support the updating of the VMH with lessons learned and new knowledge from the Virtual Local Hubs ecosystems are also foreseen. An example of such a model can be the monitoring of the effectiveness of collaboration, depending on a set of defined performance indicators.

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