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RESILINK: Increasing Resilience of Smallholders with Multi-Platforms Linking Localized Resource Sharing

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In H2020 HUBIQUITOUS he is leading the deployment of SolutionLab for providing access to IoT and AI disruptive technologies in Digital Innovation Hubs in Africa. He is also coordinating the PRIMA Intel-IrriS project on smart irrigation for smallholders, where IoT and AI technologies will be deployed for smallholders to facilitate their access to smart-agriculture.

I. INTRODUCTION

Agriculture is an important sector for income generation, employment and food security in the whole African continent. Increasing the resilience of smallholders to face unexpected crises such as COVID-19 is an increasing concern with recent numerous publications on this subject [1, 2, 3, 4]. The main difficulty resides in the fact that it is a multidimensional challenge that requires a multifaceted policy [5, 6, 7].

However, common to most crisis situations, the restrictions on movements have many impacts on the availability of distant resources such as agricultural supplies, equipment, services, labours and access to markets to name a few.

RESILINK is a Research & Innovation Action (RIA) project funded by the PRIMA organization in the context of the 2021 Section 2 call on Increasing the resilience of small-scale farms to global challenges and COVID-like crisis by using adapted technologies, smart agri-food supply chain and crisis management tools. RESILINK increases smallholder's resilience by providing continuity of access to both resources and markets in crisis situations. It empowers the local agri-food value chain model by optimizing usage of local resources, promoting and generalizing local resource sharing approach and facilitating territorial markets. This local agri-food value chain model will also be integrated with the local e-commerce, supply and distribution channels.

The concept of localized and short agri-food value chain will also impact the agro ecological system by minimizing food losses and contributing to climate and environment changes with shorter food supply chains and logistics. As a result, new and local innovative services can be identified and created, enhancing further the smallholders' agri-food chain.

To implement the generalizing local resource sharing approach, RESILINK develops a distributed digital resource management platform for real-time exchange of information on territorial resources, supplies and demands; connecting smallholders to new supply, sharing opportunities and distribution channels.

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While the ideas of connecting smallholders to market and sharing resources are not new [8, 9, 10, 11], the approach taken by RESILINK is to provide a unique platform-of-platforms capable of integrating existing or future platforms into comprehensive dashboards/portfolios. To achieve its objectives, RESILINK:

- develops a resilient RESILINK network ensuring high availability of services;
- implements the platform-of-platforms approach for large-scale adoption and sustainability;
- uses cutting-edge modern Artificial Intelligence to efficiently discover resources;
- seamlessly integrates Internet-of-Things (IoT) technologies to automatize a number of information exchanges; and runs an extensive piloting and evaluation program with smallholders;

An important contribution of RESILINK is to run an incremental piloting and evaluation program to maximize smallholders' acceptability, large-scale adoption and a sustainable usage of RESILINK's platform even in non-crisis situations. Finally, RESILINK addresses local innovation capacity and facilitates technology appropriation by developing the digital intelligent resource management platform in open-source with an extensive public API to maximize re-utilization and facilitate the integration of new platforms.

The rest of the article is organized as follows: Section Two presents an overview of the RESILINK digital platform, its main components and how seamless integration of IoT and Artificial Intelligence (AI) technologies improve resource discovering and sharing. Section Three then elaborates on the challenging research issues behind the implementation and the deployment of the RESILINK digital platform. Conclusions are presented in Section Four.

II. THE RESILINK DISTRIBUTED DIGITAL RESOURCE MANAGEMENT PLATFORM

RESILINK platform uses advanced digital technologies and state-of-the-art architectures and protocols for flexible and real-time information exchanges targeting sharing and discovery of local resources. It deploys a resilient network ensuring high availability of services where a number of light-weight platforms can be installed on local servers hosted at regional or city-level or even at the community level by socio-economic organizations such as Chambers of Commerce, cooperatives, government agencies, start-ups/SMEs, etc. The platform can also be installed in a distributed way so that several platforms can operate simultaneously to manage resources according to geographical areas. Each of the distributed platforms can share the information on territorial resources.

Figure 1 sketches the overall proposed framework with following RESILINK components: the digital resource management platform, the mobile application, the Edge-IoT components and the API and software API connectors/wrappers to link with other third-party digital platforms.

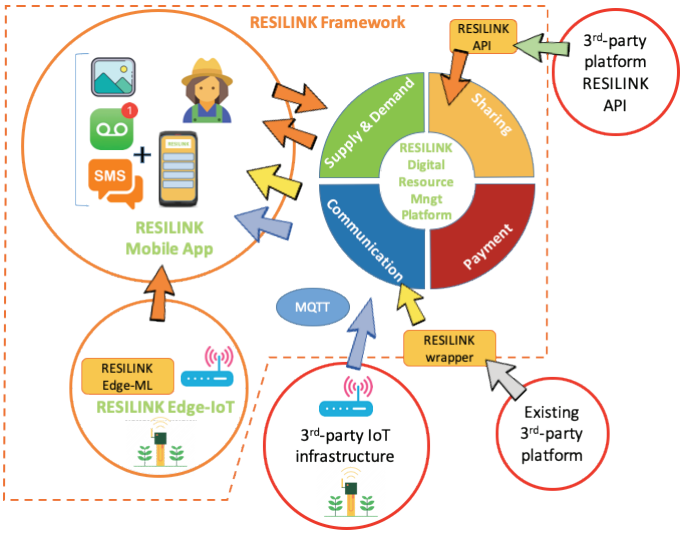

Fig. 1 – Overview of the RESILINK framework

A. Platform-of-platforms Design Approach

In order to promote the generalized resource sharing approach and to maximize long-term adoption, RESILINK also implements a platform-of-platforms design approach to propose a much wider and appealing ecosystem: (a) RESILINK wrapper components enable resources from existing digital platforms to be discovered and integrated and, (b) RESILINK's open API allows development of new digital sharing platforms that can fully inter-operate with the RESILINK digital resource management platform to benefit from the RESILINK community. The lightweight, highly scalable and standardized MQTT protocol [12] is used as the foundation for the open API to provide the full set of functionalities. A limited set of functionalities can be provided with the more traditional REST API.

B. Integrating IoT and AI Technologies

Smallholders will interact only in a very simple manner with the digital resource management platform, indicating available resources and offered resources. Based on previous experience gained from more than six years of international collaborations with smallholders in both North and Sub-Saharan African countries, the authors know that acceptability and usage can be low if the proposed interface is too complex.

In RESILINK, while inputs from end-users are kept simple, cutting-edge digital technologies in IoT, Linked Data, Decision Support System (DSS) and AI are designed to provide advanced features to efficiently connect smallholders to resources, matching demands to offers in an intelligent manner. For instance, IoT devices (such as push buttons, tags readers, environmental sensors and field sensors) deployed for specific tasks can automatize a number of simple processes. Then, Linked Data and DSS are integrated into low-cost and compact IoT edge gateways can process multiple knowledge streams to efficiently notify smallholders (alarm, SMS,...) on relevant events such as discovery of resources, availability of resources, request for resources, localization of resources, etc.

In Figure 1, the RESILINK Edge-IoT component takes care of IoT and AI features and is deployed in a fully edge approach by embedding them into the IoT gateway itself, meaning that the RESILINK digital platform is also distributed in a number of edge components that run on IoT gateways.

III. RESEARCH and DEVELOPMENT CHALLENGES

A. A Lightweight Edge-enabled Platform

The whole RESILINK framework providing resilience to smallholders should itself be resilient to crisis situations. In RESILINK, the digital resource management platform is the central component connecting smallholders to territorial resources and the normal operation mode is to deploy the digital resource management platform on local servers at regional or city level or community level. Therefore, there is a challenging research issue on building such a distributed and resilient network of lightweight digital platforms while preserving consistency and synchronization between the Edge-IoT component of the RESILINK digital platforms running on Edge-IoT gateways.

B. Increased Robustness with Blockchain-based Transactions

As the core of RESILINK digital platform is to handle a large number of transactions for sharing agri-food chain resources, it is quite natural to adopt a Blockchain approach [13, 14] to ensure robustness of the decentralized transaction system. Blockchain technologies have been investigated in a large variety of applications [15] and RESILINK, with its private and decentralized architecture particularly investigates how private/permissioned, peer-to-peer and hybrid Blockchain frameworks provide a possible solution to problems with a single point of failure and bottleneck.

C. Data Privacy and Traceability

While transactions and related databases operations can be made more robust with Blockchain, more complex data management features are highly desirable when dealing with smallholders' data on resource demands and sharing offers, including for instance those from automatized collected IoT data [16]. Such concerns on data management are becoming more and more critical especially as an increasing number of countries are adopting regulations similar to the EU General Data Protection Regulation (GDPR) [17]. By proposing and implementing efficient data management methods, RESILINK would increase the level of trust with smallholder users, therefore maximizing large-scale adoption of the technology. Data privacy, data provenance, data traceability as well as innovative digital identity approaches are the challenging research issues that will be conducted by RESILINK.

D. Investigating innovative AI approaches

While the integration of AI technologies may seem nowadays easier with the increased maturity of the research domain, the traditional data models in AI usually assume a simple data exchange model. In these traditional models, one entity would build and transfer sets of data to another entity which is in charge of cleaning and fusing the data. The AI data processing chain could include additional entities, each providing at its level its own AI approach to build new models for other users. When implemented on top of a highly-distributed architecture, with

the constraint on secured data management, this traditional way of running AI has to face data fragmentation and data isolation issues. Recently, decentralized AI approaches have been proposed to tackle these issues and RESILINK will investigate federation-based AI [18, 19] or gossip-based AI approaches [20].

IV. CONCLUSIONS

This article presented a general overview of the PRIMA RESILINK project to increase smallholder's resilience by providing continuity of access to both resources and markets in crisis situations. It proposes a generalized local resource sharing approach for the smallholder's agro-food chain and has the clear ambition to make digital smart technologies attractive and accessible to smallholders.

There are several expected impacts. First, the authors expect RESILINK to have an important impact on sustainability and competitiveness by promoting digital smart technologies to improve efficiency and by creating new business opportunities towards the smallholder communities. Second, RESILINK can also directly improve efficiency of small-scale farming system as generalized usage of local resources can reduce both delays and cost of access to resources. Finally, while RESILINK focuses on a generalized resource sharing platform for smallholders, the technology building blocks developed by RESILINK can easily be adapted to a larger variety of application domains. The large networks of actors built during the project will create synergies, increasing the likelihood of innovative third-party applications by local entrepreneurs for instance.

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