Invention ID: **INV2025-123**

Title: **Decentralized Autonomous Building Cyber-Physical System (DAB-CPS): An Integrated Framework for Generative AI and Blockchain-enabled Smart Building Infrastructure**

Technology ID: **25-144**

Submitted By: **Alireza Shojaei**

Original Submitted Date: **4/18/2025**

Stage: **Approved**

Type: **Intellectual Property (IP) Disclosure**

Updated Date: **4/19/2025**

Last Submitted Date: **4/18/2025**

Status: **Approved**

Introduction

Instructions
Virginia Tech recognizes the value of intellectual property (IP) and is committed to promoting the value of its intellectual property portfolio through its university affiliated corporation, Virginia Tech Intellectual Properties, Inc. (VTIP). Faculty and staff at Virginia Tech have an obligation to disclose research results that may be commercially or industrially useful. Completing and submitting this disclosure is necessary to enable Virginia Tech to identify and legally protect intellectual property and to comply with government and industry contractual requirements. This is an important legal document that should be completed when something new and useful has been conceived or developed, or when unusual, unexpected, or unobvious research results have been achieved.

This online submission portal is an internal Virginia Tech form used to provide a written record of your IP. The information contained in this disclosure will be used to establish a record of the date of conception, evaluate the technology as to its patentability and commercial potential, obtain information necessary to file patent applications or other forms of IP protection, comply with sponsor reporting requirements, and to identify potential licensees.

NOTE: Submission of this form DOES NOT constitute a patent filing at the patent office.

Virginia Tech is required by federal law to report income along with Social Security numbers for all employees and students to whom compensation is paid. The University may disclose your Social Security number when required by law, or to external entities acting as the University's contractor or agent. Your VT ID number will be used by VTIP to verify your Social Security number.

The completion of this disclosure is the beginning of the IP originator's responsibility in this process. The University encourages all IP originators to monitor the progress of their disclosure through communications with VTIP and this Inventor Portal as IP originators are often the best sources of information concerning the capabilities and commercial potential of the IP. Please reach out to a member of the licensing team or email vtippatents@vtip.org if you have any questions about the invention disclosure process.

Virginia Tech's Policy on Intellectual Property
http://www.policies.vt.edu/13000.pdf

Title and Description of Intellectual Property

Title and Description
When you created this disclosure, you were asked to include a title; that title is still editable above until you submit this disclosure for review. Ideally, the title of your disclosure should be both descriptive and concise.

In the "Brief Description of IP" field, include the key features of your invention, its most important uses, and how it improves on existing technology or practice. In a subsequent section of this form, you will be asked to attach supporting documentation that can provide a more complete description of the invention (i.e. manuscripts, diagrams, or data) and that describe its advantages and differences over existing technology.

Brief Description of Innovation:

This intellectual property discloses a novel framework that integrates blockchain technology, Decentralized Autonomous Organizations (DAOs), Large Language Models (LLMs), and digital twins in enabling a decentralized and autonomous building cyber-physical system (DAB-CPS). The DAB-CPS framework enables building infrastructure to be self-governed through decentralized decision-making, financially self-sustaining through automated space rental systems, and operationally autonomous through LLM-powered virtual assistants that control building systems based on environmental conditions and user preferences. The system includes a full-stack decentralized application (Dapp) with components for governance, space reservation, digital twin visualization, and AI-assistant interactions.

Documents

Comprehensive Description of the IP
Upload a document that includes a detailed description of your experimental results, figures and/or tables that support your conclusions and proposed uses. Feel free to include in the document other possible conceptual uses in addition to the ones that you have already demonstrated.

Many funding agencies require a description that is between 2 and 20 pages in length to satisfy reporting requirements. Review of the disclosure and protection of the intellectual property will be delayed if there is no comprehensive description attached.

Documents

File Name	Created By	Date Created
Leveraging Decentralized Autonomous Organizations, Large Language Models, and Digital Twins Toward Autonomous Building Cyber-Physical Systems.pdf	Alireza Shojaei	4/18/2025
Leveraging Decentralized Autonomous Organizations, Large Language Models, and Digital Twins Toward Autonomous Building Cyber-Physical Systems.docx	Alireza Shojaei	4/18/2025

Other Documents
For some disclosures, additional documents will be required. Those can be uploaded here as well.

Inventors

Inventorship
Inventorship is determined by criteria specified in U.S. law, specifically 35 U.S.C. U.S. patents are granted only to the true inventor(s). An inventor would be the person who, alone or in combination with others, discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof. It is important to note that authorship does not necessarily mean inventorship, and great research is not necessarily patentable.

The correct listing of all inventors is very important; a patent can be invalidated for the failure to list all of the proper inventors. Unlike publication authorship, the order in which inventors are listed on a patent application does not imply importance or contribution. Inventors may need to be added to an application or initially named inventors removed from the patent based upon the final claims in the patent.

Originator(s)/Inventor(s)

- **An inventor is a person who has conceived of or contributed to an essential element of the invention during the evolution of the technology conception or reduction to practice.**
- **List originators/inventors in the order you would like them to appear on a patent application or other form of intellectual property protection. The first listed inventor will be used as VTIP's primary point of contact for management of the disclosure. If you would like to specify an additional or alternative point of contact for invention management, include relevant directions as a remark below.**
- **List all originators/inventors, even if not associated with Virginia Tech.**
- **University originators/inventors or contributors should keep VTIP informed of any change in address so that VTIP can distribute royalty shares**

Royalty Share
All royalties, rents, payments, or any cash receipts from the sale, assignment, transfer, licensing or use of the disclosed intellectual property shall be shared with inventors in accordance with VT Policy 13000: Policy on Intellectual Properties.

NOTE:

- **Percentages must total to 100%.**
- **Make sure to include non-university inventors, but set their royalty share to 0%.**
- **If there are contributors who are not inventors but should be included in the royalty share, include them here but make sure to attach a remark to this form noting that they should not be included on patent applications.**

Any share of revenues to be paid to the inventors shall be distributed as follows:

Inventors

First Name	MI	Last Name	Email	Contribution	Address
Alireza		Shojaei	shojaei@vt.edu	50.00 %	880 Plantation rd Apt 311 Blacksburg VA *United States
Reachsak		Ly	reachsak@vt.edu	50.00 %	800 Washington St SE Apt2 Blacksburg VA

Relevant Sponsorship and Other Agreements

Grants and Other Funding Agreements
Identify and list all grants, contracts, and other sources of funding that contributed to the conception or development of the invention you're disclosing here. Note that accurate and complete sponsorship information is required to fulfil Virginia Tech's obligations under sponsored research grants and contracts.

Was this IP developed with the use of any external (public or private) funding?

No

Relevant Sponsorship and Other Agreements

Grant / Contract No	Title	Granted Date	Funding Institution	Investigator	Internal ID

Was this IP developed using any Virginia Tech internal funds?

No

Have you entered into any other agreements (e.g. material transfer agreement (MTA), memorandum of understanding, consortium agreement, consulting agreement, etc.) that may grant anyone outside of Virginia Tech rights of any sort to this IP?

If you have any questions about what agreements might be relevant to disclose here, please contact VTIP or a member of the licensing team.

No

Dates of Note

Dates of Conception, Reduction To Practice, and Public Disclosure
Like inventorship, Conception is defined in U.S. patent law and involves the formulation of a definitive idea of the complete invention and how it works in the mind of the inventor(s). An invention is considered complete and operative if the description would enable one of "ordinary skill in the art" to build the invention or perform the invented method successfully without extensive research or experimentation. If extensive research or experimentation is necessary to reduce the invention to practice, then the conception is probably not complete.

Reduction to practice can be accomplished two different ways. Actual reduction to practice is a physically building the invention or performing the invented method for its intended use. Constructive reduction to practice is essentially clearly describing the invention in writing.

The first written publication or oral public disclosure is the first time any member of the general public, without an obligation of confidentiality, would have been able to legally gain access to your written or printed enabling description of the invention, or the first time the invention is featured in an oral presentation to the general public.

List dates for conception and reduction to practice below and provide copies of any publications, abstracts, or other forms of public disclosure that may exist. If you have not publicly disclosed the invention but you plan to, indicate that below as well. Accurate data is essential, as public disclosures affect patent rights in the U.S. and abroad.

When was this IP conceived?

2/1/2024

Has this conception been documented?

Yes

If Yes, where was the conception documented?

Papers

Has this IP been reduced to practice?

Yes

If Yes, when was this reduced to practice??

5/1/2024

Have you published your IP?

No

Do you plan to publish your IP?

Yes

If Yes,
Please create a remark below describing your publication plans. If you have a manuscript or abstract submitted, upload that in the documents section above.

Export Control

Export Control
Virginia Tech fully supports compliance with United States export control and sanctions laws. Export controls are U.S. laws and regulations that regulate and restrict the release of critical technologies, information, and services to foreign nationals, within and outside of the United States, and foreign countries for reasons of foreign policy and national security. Sanctions are prohibitions on transactions that can be either comprehensive or selective, using the blocking of assets and trade restrictions to accomplish foreign policy and national security goals. Procedures have been enacted to establish, document, and implement actions needed to ensure that the university, and its employees and students, remain in full compliance with International Traffic in Arms Regulations (ITAR), Export Administration Regulations (EAR), Foreign Assets Control Regulations (FACR) and/or other applicable export control or sanction related regulations.

Is this IP likely to have an Export Control Sensitivity?
Please check Yes if you believe the IP may be subject to export controls (e.g. International Traffic In Arms Regulations (ITAR), Export Administration Regulations (EAR), Nuclear Regulatory Commission).

If your project is not considered fundamental research and required the establishment of a technology control plan or faculty agreement with the Office of Export and Secure Research Compliance (OESRC), please check Yes.

No

Determination of IP Ownership and Eligibility for Royalty Sharing

Technology Ownership Determination
This section needs to be completed by the university IP originators and reviewed by their home Department Head(s)/Center Director(s). If the originators of the IP are from multiple departments or centers within the university, approval must be obtained by all relevant supervisors. If one of the IP originators is a Department Head or Center Director, then a signature must be obtained from their administrative supervisor.

Were university resources, such as the time and services of university employees, or facilities, such as equipment, materials, funds, information, or the time or services of other university employees, used in the development of the IP?

Yes

Does the work performed in the development of this intellectual property fall within the range of the normal activities expected of the IP originators by their appointment or employment by the university (i.e. teaching, research, public service)

Yes

Did the IP originators work on this project during their normal university working hours?

Yes

OWNERSHIP DETERMINATION

University Owned

Virginia Tech shall share any royalty income derived from this disclosure according to VT Policy 13000.
To ensure proper distribution of royalties, make sure that all Royalty Sharing parts of this disclosure are filled out completely.

Review by Department Head/Center Director
Should any royalties be earned from this disclosure, the home Department/Center of each IP originator is entitled to a 10% share divided equally among the departments/centers. Please indicate the home Department/Center Organization Code as well as the responsible supervisor who oversees the Department/Center. The Budget Office will establish the fund based on activity and notify affected departments/centers.

Be sure to include the listed supervisor(s) as Subscribers in the next section so that they can receive digital requests for their approval of this disclosure.

Department Head	Dept/Center	Organization Code
Georg Reichard	Building Construction	038703
Brian Kleiner	Myers-Lawson School of Construction	038700

Remarks

Remarks

By	Comment	Date Added
Alireza Shojaei	The paper discussing the work is under review currently at the Automation in Construction journal. A shorter version of the work without evaluation was submitted to arxiv on 25 Oct 2024. https://arxiv.org/abs/2410.19262	4/18/2025

Subscribers

Subscribers
Subscribers do not need to have Inventor Portal user accounts to receive emails but will need to have an account if they want to log in and view the submission in more detail. Anyone with a Virginia Tech PID can create an Inventor Portal account.
Add individuals that you would like to have notified by email of events and actions that take place for this disclosure.

In addition to Inventors who are automatically added as Subscribers, there are three more types of disclosure "Subscribers":

- **Followers do not need to sign anything. They will receive emails when key events happen to the disclosure, and they do not need to have an Inventor Portal account.**
- **Preparers will need to sign to attest to the accuracy of the disclosure, so they need to have an Inventor Portal account.**
- **Department Heads will need to sign the disclosure to indicate approval; they need to have an Inventor Portal account.**

Marketing Targets

Describe the current and/or potential commercial applications for this intellectual property.

The DAB-CPS framework represents a paradigm shift in building management and operation, with transformative commercial applications across the built environment sector. This technology enables autonomous buildings powered by generative AI, where large language models facilitate intuitive human-building interactions through natural language processing while simultaneously managing building systems with human-like reasoning capabilities. The framework also creates financially self-sustaining physical spaces that generate and manage their own revenue streams through blockchain-based rental systems, essentially allowing buildings to "own themselves" and cover their operational costs independently. This technology aims to transform traditional building into community-governed infrastructure and particularly applicable to public building infrastructure, such as community centers, libraries, public facilities, and shared municipal spaces, where stakeholders collectively make decisions about building operations, maintenance priorities, and resource allocation through transparent and decentralized blockchain voting mechanisms. The AI components of the system can be applied to a wide variety of building types—from commercial offices to educational institutions, healthcare facilities to residential complexes as well as commercial building , where it can enhance energy efficiency and occupant comfort through autonomous environmental control that adapts to real-time conditions.

List any potential contacts that you believe may be interested in this technology or may have background and expertise in the technology area(s) related to this intellectual property.
1 PassiveLogics - A building autonomy company developing digital twin platforms for smart buildings that could leverage our LLM integration approach.
2 Siemens Building Technologies - Their smart building division could incorporate our LLM framework into their existing building management systems.
3 Johnson Controls - A global leader in building automation systems with interests in AI-enhanced building management technologies.
4 Honeywell Building Technologies - Develops intelligent building solutions that could benefit from our LLM-based virtual assistant and automation capabilities.
5 ABB Smart Buildings - Offers building automation solutions that could incorporate our natural language processing approach.
6 Schneider Electric - Their EcoStruxure Building platform could be enhanced with our LLM-based autonomous control systems.
7 Autodesk - Digital twin and BIM technologies
8 IBM Watson IoT - AI and IoT solutions for smart buildings

List any potential contacts that you believe may be interested in this technology or may have background and expertise in the technology area(s) related to this intellectual property.

Marketing Targets

Company	Contact	Email

List any conferences, meetings, or trade shows that you and/or industry representatives attend that may help us make contacts to market, commercialize, and learn more about this intellectual property.

Construction Blockchain Conferences
ASHRAE Annual Conference
Greenbuild International Conference and Expo
International Convention & Trade Show - IIBEC Convention
ACM BuildSys (Conference on Building Systems)
Web3 Summit

Provide a brief (approximately 250 words), non-confidential overview of the intellectual property that may be used to for marketing purposes and to solicit interest from potential licensees and respond to inquiries.

The Decentralized Autonomous Building Cyber-Physical System (DAB-CPS) aims to transform conventional buildings into self-governing building with AI-powered automation and capable of autonomous financial and operational management. This integrated framework combines blockchain-based decentralized governance with advanced artificial intelligence to create buildings that can manage themselves. At its core, DAB-CPS incorporates four components: (1) A blockchain-based governance platform enabling transparent, collective decision-making about building management and resource allocation; (2) An automated space reservation and payment system that allows buildings to generate and manage their own revenue streams; (3) A real-time digital twin providing comprehensive visualization of environmental conditions and space utilization; and (4) LLM-powered virtual assistants and AI agents that enable intuitive voice and text interactions with building systems while autonomously managing environmental parameters.

Acknowledged by Inventors:

By digitally signing this invention disclosure submission, all Virginia Tech IP originators agree to assign, and do hereby assign, all right, title and interest to this intellectual property to Virginia Polytechnic Institute and State University (VT) and agree to execute all documents as requested, assigning to VT their rights in any patent application or other intellectual property protection filed on this IP disclosure, and to cooperate with Virginia Tech Intellectual Properties, Inc. (VTIP) in the protection of this intellectual property. By signing below, the IP originators confirm that prior to the execution of this disclosure, they have not granted the right or license to make, use, or sell the disclosed intellectual property to anyone except to VT, nor have they otherwise encumbered their rights, title, and interest in the disclosed intellectual property, nor will they execute any instrument in conflict with this agreement.

All royalties, rents, payments, or any cash receipts from the sale, assignment, transfer, licensing or use of the disclosed intellectual property shall be shared with inventors in accordance with VT Policy 13000: Policy on Intellectual Properties. All Virginia Tech IP originators or contributors to of the intellectual property described in this disclosure agree that any share of revenues to be paid to the IP originators or creators shall be distributed as indicated in the Royalty Share section of the Inventorship grid for this disclosure.

Reviewed by Department Head/Center Director:

By digitally signing this invention disclosure submission, I attest that I have reviewed the details associated with the IP disclosed including but not limited to inventorship and university ownership claims to the IP, and I agree with the disclosed information. I understand that if I am both a relevant department head and an IP originator on this disclosure, my administrative supervisor must also approve this disclosure. Should any royalties be earned from this disclosure, the home Department/Center of each IP originator is entitled to a 10% share divided equally among the departments/centers.

Acknowledged by Inventors: By digitally signing this invention disclosure submission, all Virginia Tech IP originators agree to assign, and do hereby assign, all right, title and interest to this intellectual property to Virginia Polytechnic Institute and State University (VT) and agree to execute all documents as requested, assigning to VT their rights in any patent application or other intellectual property protection filed on this IP disclosure, and to cooperate with Virginia Tech Intellectual Properties, Inc. (VTIP) in the protection of this intellectual property. By signing below, the IP originators confirm that prior to the execution of this disclosure, they have not granted the right or license to make, use, or sell the disclosed intellectual property to anyone except to VT, nor have they otherwise encumbered their rights, title, and interest in the disclosed intellectual property, nor will they execute any instrument in conflict with this agreement. All royalties, rents, payments, or any cash receipts from the sale, assignment, transfer, licensing or use of the disclosed intellectual property shall be shared with inventors in accordance with VT Policy 13000: Policy on Intellectual Properties. All Virginia Tech IP originators or contributors to of the intellectual property described in this disclosure agree that any share of revenues to be paid to the IP originators or creators shall be distributed as indicated in the Royalty Share section of the Inventorship grid for this disclosure. Reviewed by Department Head/Center Director: By digitally signing this invention disclosure submission, I attest that I have reviewed the details associated with the IP disclosed including but not limited to inventorship and university ownership claims to the IP, and I agree with the disclosed information. I understand that if I am both a relevant department head and an IP originator on this disclosure, my administrative supervisor must also approve this disclosure. Should any royalties be earned from this disclosure, the home Department/Center of each IP originator is entitled to a 10% share divided equally among the departments/centers.

Digitally signed on 4/19/2025

Alireza Shojaei (50.00 %) Date

Acknowledged by Inventors: By digitally signing this invention disclosure submission, all Virginia Tech IP originators agree to assign, and do hereby assign, all right, title and interest to this intellectual property to Virginia Polytechnic Institute and State University (VT) and agree to execute all documents as requested, assigning to VT their rights in any patent application or other intellectual property protection filed on this IP disclosure, and to cooperate with Virginia Tech Intellectual Properties, Inc. (VTIP) in the protection of this intellectual property. By signing below, the IP originators confirm that prior to the execution of this disclosure, they have not granted the right or license to make, use, or sell the disclosed intellectual property to anyone except to VT, nor have they otherwise encumbered their rights, title, and interest in the disclosed intellectual property, nor will they execute any instrument in conflict with this agreement. All royalties, rents, payments, or any cash receipts from the sale, assignment, transfer, licensing or use of the disclosed intellectual property shall be shared with inventors in accordance with VT Policy 13000: Policy on Intellectual Properties. All Virginia Tech IP originators or contributors to of the intellectual property described in this disclosure agree that any share of revenues to be paid to the IP originators or creators shall be distributed as indicated in the Royalty Share section of the Inventorship grid for this disclosure. Reviewed by Department Head/Center Director: By digitally signing this invention disclosure submission, I attest that I have reviewed the details associated with the IP disclosed including but not limited to inventorship and university ownership claims to the IP, and I agree with the disclosed information. I understand that if I am both a relevant department head and an IP originator on this disclosure, my administrative supervisor must also approve this disclosure. Should any royalties be earned from this disclosure, the home Department/Center of each IP originator is entitled to a 10% share divided equally among the departments/centers.

Digitally signed on 4/20/2025

Reachsak Ly (50.00 %) Date

By signing below, all Virginia Tech IP originators agree to assign, and do hereby assign, all right, title and interest to this intellectual property to Virginia Polytechnic Institute and State University (VT) and agree to execute all documents as requested, assigning to VT their rights in any patent application or other intellectual property protection filed on this IP disclosure, and to cooperate with Virginia Tech Intellectual Properties, Inc. (VTIP) in the protection of this intellectual property. By signing below, the IP originators confirm that prior to the execution of this disclosure, they have not granted the right or license to make, use, or sell the disclosed intellectual property to anyone except to VT, nor have they otherwise encumbered their rights, title, and interest in the disclosed intellectual property, nor will they execute any instrument in conflict with this agreement.

Not signed yet

Georg Reichard (Department Head) Date

By signing below, all Virginia Tech IP originators agree to assign, and do hereby assign, all right, title and interest to this intellectual property to Virginia Polytechnic Institute and State University (VT) and agree to execute all documents as requested, assigning to VT their rights in any patent application or other intellectual property protection filed on this IP disclosure, and to cooperate with Virginia Tech Intellectual Properties, Inc. (VTIP) in the protection of this intellectual property. By signing below, the IP originators confirm that prior to the execution of this disclosure, they have not granted the right or license to make, use, or sell the disclosed intellectual property to anyone except to VT, nor have they otherwise encumbered their rights, title, and interest in the disclosed intellectual property, nor will they execute any instrument in conflict with this agreement.

Digitally signed on 4/21/2025

Brian Kleiner (Department Head) Date

Digitally signed on 4/19/2025

Alireza Shojaei (Preparer) Date