Fostering Open Science by using Blockchain Technology

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Problem

- **Trust problems** arising from missing reproducibility, traceability, and theft of scientific results
- **Plagiarism**, i.e., use of ideas, concepts, words, or structures without appropriately acknowledging the source
- **Lack of transparency** in peer reviewing and reputation measures
- **Quality of research** due to irreproducible results

Research Questions

- How can blockchain technology (BT) foster open Science?
- Which challenges counter the dissemination of blockchain-based applications?

Method

- Evaluation of existing approaches according functionality, underlying blockchain, consensus method, research cycle target phase, and maturity level
- Propose future possible applications and identify challenges of BT

(Open) Science / Research Cycle
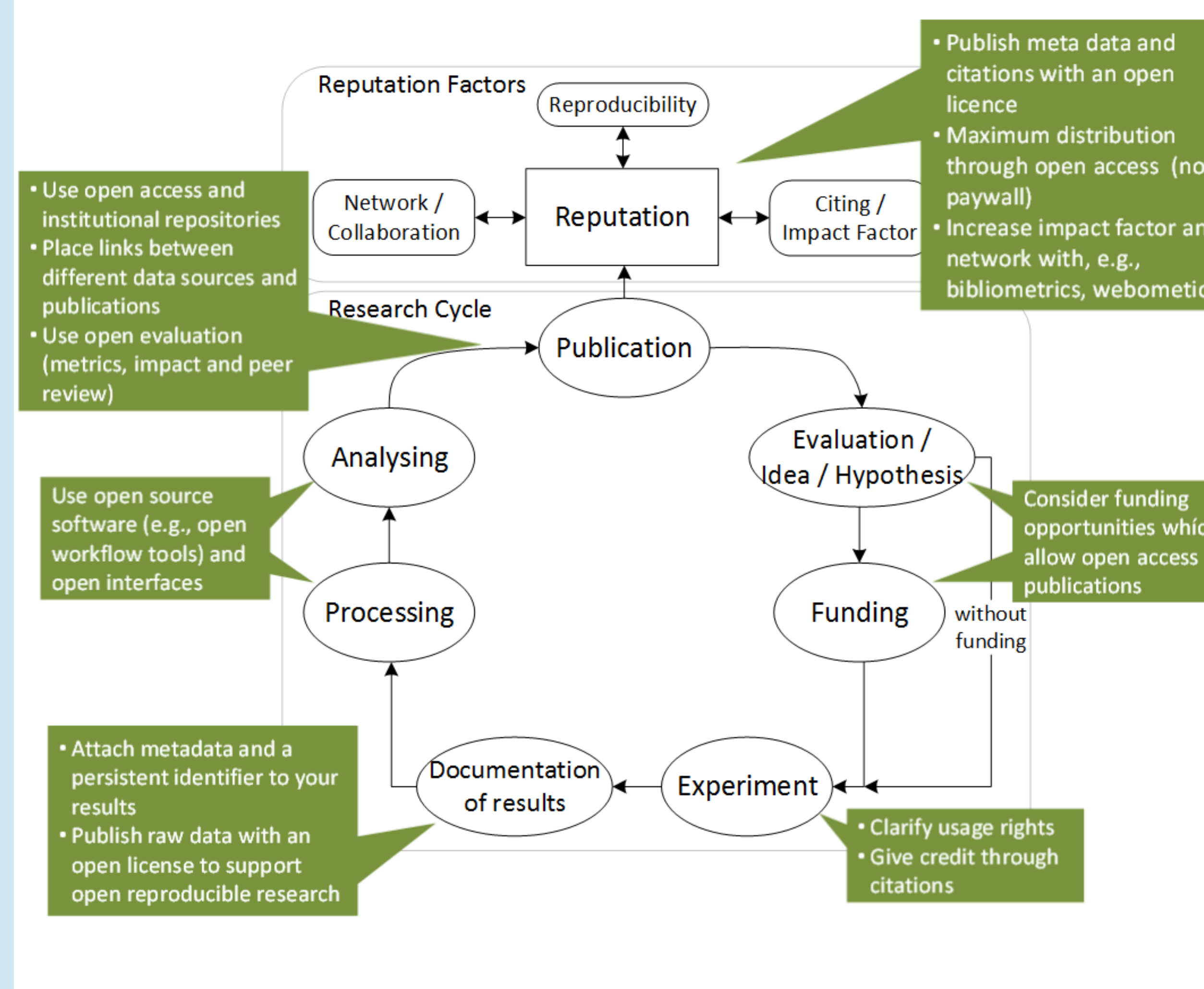
Applications Overview (Excerpt)

Project / Application	Function / Purpose	Research Stages	Project Stage
OriginStamp	Timestamping of digital assets (Proof-of-Existence)	All Stages	Deployed
CryptSubmit	Timestamping of manuscript submissions and peer-reviews	Publication	Prototype
VirtualPatent	Timestamped sharing and discussing ideas and research, improving the traceability of online shared ideas	All Stages	Prototype
Publish and Evaluate Onchain	Open Access platform for scholarly publications, reputation system with a ranking algorithm, evaluation process of research manuscripts	Publication and Reputation	Concept
Bernstein	Blockchain certificates for digital assets and intellectual property (Proof-of-Ownership, Existence, and Integrity), Verification process for issued certificates	Evaluation/Idea and Publication	Deployed
Academic Endorsement System	Transparent, expeditious appraisal for all kind of scientific output, creating new metrics to measure the impact factor of researchers, a new incentive system to reward researchers for their output.	Publication and Reputation	Concept
Golem	Decentralized network to provide computational power from the networks peers that is usable for testing algorithms and calculations	Experiment, Processing, and Reputation	Prototype
Hyperledger Fabric	Flexible infrastructure for setting up custom blockchains with support for smart contracts	All Stages	Deployed
Matryx	Collaboration platform/marketplace for open research projects and submitted solutions	Processing, Publishing, and Reputation	Prototype

Ideas and Visions

Research Studies using Blockchain Technology

- Concept to **create study designs** and related hypothesis **on a blockchain** so a timestamp of it gets created. Once created they cannot be changed so this approach will **prevent hypotheses from being subsequently changed to fit** in with the available results
- When submitting a paper, the **study results** can be included so they can be **transparently proofed** by the created tamper-proof timestamps and hashes stored on the blockchain

Combining Internet of Things and Blockchain Technology

- There is potential to use **laboratory devices**, sensors, and other measurement equipment **in combination with BT**
- Devices could **automatically store measurements tamper-proof** on a blockchain
- **Raw and meta data** could be **added to the submission** of the final paper, so **peer-reviewers and readers** are **able to verify the data**

Challenges

Correctness and Security of Smart Contracts

- **Smart contracts often manage valuable resources** (information or money in the form of cryptocurrencies) which could become **inaccessible** (even for the owner) or **stolen if functional correctness and security are not given**
- Smart contracts **cannot be modified once they are deployed** (potential bugs live forever). Thus, verification of correctness and security is crucial to smart contracts

Trust in Blockchain Technology

- **Critical-mass problem**: BT-based systems will become accepted only if there is a sufficient number of researchers and other participants of the research cycle that trust the system and participate. Thus, a reasonable question, that needs to be addressed, is: 'Why should anyone **trust a complex technical system rather than other people or institutions**?'

Conclusion

- Due to the conducted analysis of existing blockchain projects and applications, we see a **great potential** for BT to **mitigate currently existing problems in science**.
- **Replication of study results and experiments** can be significantly simplified by a **chronological, tamper-proof, and transparent recording** of all research activities on a blockchain (see PROBOS and Matryx).
- BT can **increase transparency and trust** (see CryptSubmit).
- The **capability** of the BT is **by far not exhausted yet** and **allows** to design and create much **more applications that are useful** in science and beyond.
- BT is still in an **early stage of development** and several **challenges** need to be addressed in the future to use the full potential of the technology.