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Decentralized Service Registry and Discovery in P2P Networks Using Blockchain Technology

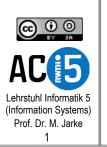
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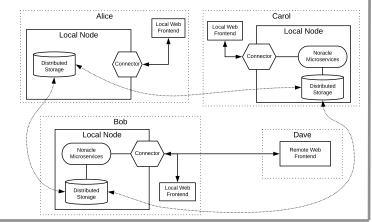
Decentralized

Service Registry

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Motivation

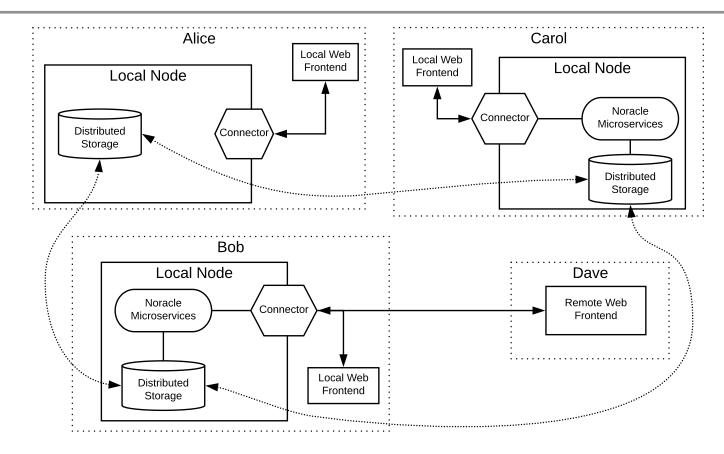
- Communities of Practice (CoPs)^[Wenger98] benefit from decentralized infrastructure
 - shared burden of hosting
 - natural scalability with community growth
 - self-governance and control over own data
- Previous work: Microservice Infrastructure for distributed CoPs^[de Lange et al.18]
 - Self-hosted infrastructure for European Voluntary Service (EVS) training courses
 - Various evaluations with several communities over the course of a two year usage span



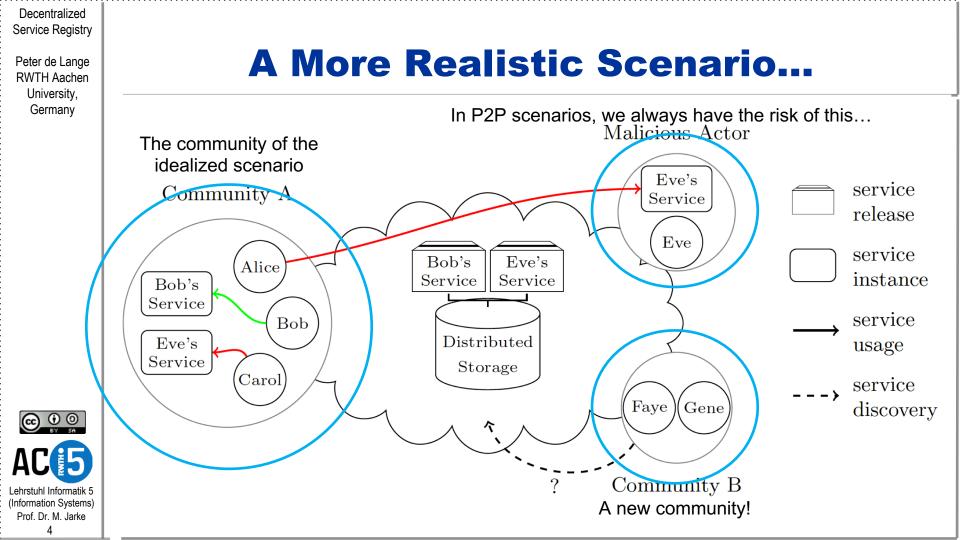


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An Idealized Scenario...







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Research Questions

1. How can we design a decentralized service registry that facilitates trust between service authors, users, and the published services?

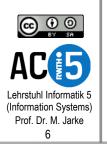
2. How can we help users discover relevant services both within and beyond community boundaries?



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Thus We Need A Decentralized Service Registry That...

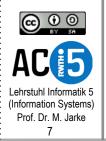
- Gives authors control over service update process and the ability to establish a reputation
- Lets users verify origin and history of service releases
- Enables service discovery
 - 1. programmatically (via an API)
 - 2. for humans (via Web-based node front-end)



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So Why Not Use The DHT?

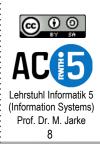
- DHT lacks wildcard queriability \rightarrow no search
- Sybil attacks:
 - create many "fake" identities in a network
 - influence majority decisions
- Byzantine fault:
 - nodes can exhibit arbitrary (mis-)behavior
 - misbehaving nodes can cooperate



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Blockchain

- Decentralized data structure that is robust against Sybils and Byzantine faults (if majority of computing power "behaves")
- Proof-of-Work consensus system
 - writing requires solving a cryptographic puzzle
 - "voting power" corresponds to computing power
- Ethereum: general purpose blockchain supporting smart contracts
 - scripts stored on the blockchain
 - their functions are invoked by special transactions
 - allow us to encode rules, such as ownership of entries



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Two Smart Contracts: Decentralized Identity Management

- Secure identities are the foundation for trust
- Usernames can be registered on a first come, first served basis
- Stored on blockchain, smart contracts enforce ownership:
 - updating the entry requires private key
- Users have control over their data and can reveal as much as they like



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Two Smart Contracts: Service Registry

- Users can register service names
- The owner of a service name can then publish releases
- Releases include metadata for service discovery
 - for end-users: title, description, project URL
 - for services and developers: default class, entrypoint URL
- Running service instances are announced to the registry



Decentralized Service Registry Peter de Lange RWTH Aachen University, Germany	Smart Contracts							
Eehrstuhl Informatik 5 (Information Systems)	User Contract User Registration username agent ID public key Ethereum address timestamp email address (entri	Service Contract Service Registration package name author timestamp	service Release package name version timestamp <i>title</i> <i>description</i> <i>default class</i> <i>source code repository</i> <i>frontend entrypoint</i> red as references to DHT)	Service Announcement class name package name version node ID timestamp				

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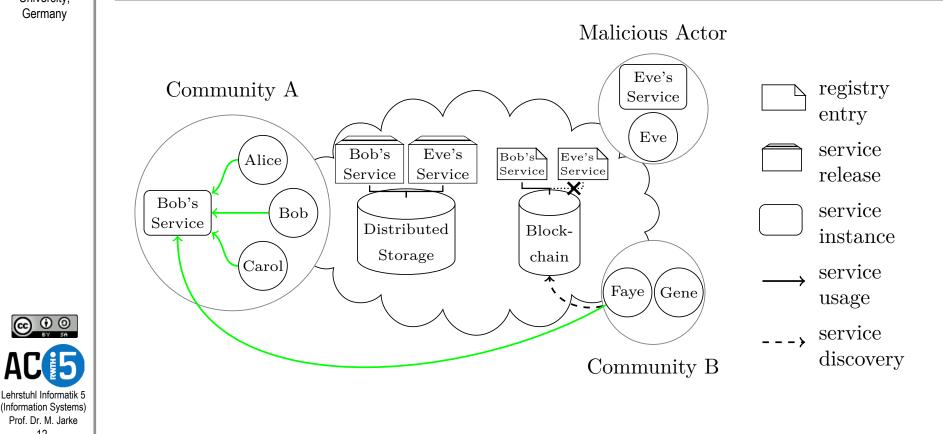
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Prof. Dr. M. Jarke 12

Same Use Case With BC-Service Registry



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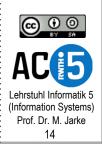
Service Explorer

Menu	las2peer Node Front-End)				
Welcome Status	Distributed Noracle					
	➡ i5.las2peer.services.noracleService					
View Services	Author: tjanson					
Publish Service	Latest version: 0.7.0 published 27/01/2019, 16:23:33 🕦					
Agent Tools	Are you thinking what I'm thinking? Inquiry skills are an essential tool for assessing and integrating knowledge. In facilitated face-to-face settings, inquiry skills were improved successfully by using a " question-based dialog " and its resulting visual representation. Service consists of 6 microservices 0 running locally on this node, 4 running remotely in network					
	START ON THIS NODE STOP OPEN FRONT-END					
	i5.las2peer.services.findATutorService					
	Author: john Latest version: 1.0.0 published 28/01/2019, 11:14:35 👔					
	Get in touch with tutors for subjects you need help in, and offer to help others.					
	 Service consists of 1 microservice 1 running locally on this node, 0 running remotely in network Service available locally, authenticity verified 					
	Microservice 🙏 Node ID 🕓 Last announced					
	FindATutorService 🕐 BADCCCCA 29/01/2019, 20:53:17					
	Microservice running locally					
	START ON THIS NODE STOP OPEN FRONT-END					

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Implementation: Components & Technology

- Service registry (Solidity Smart contract scripting language)
 - stores and retrieves data on/from private blockchain
- Registry gateway (Java)
 - middleware layer, interfacing with DHT storage and Ethereum client
 - stores data blobs in DHT, references them on blockchain
 - provides JSON-based API
- Service explorer (*LIT Element Web Component*)
 - added to existing node Web front-end



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User Evaluation

- Do users understand and appreciate the service registry concept?
- What are their motivations, how do they benefit, and what improvements do they suggest?
- Sessions
 - 11 participants using a network of 5 permanent nodes
 - hands-on tasks using the Service Explorer: explore & discover, register, start & publish a service



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User Evaluation Results

Understood n	ode ownership		3			
Easy to publis	sh own service in	the network		3.27		
Easy to start	own services					4.27
Interface help	ed understand wh	nere services a	e running			4.27
Clear by whor	n each service wa	s published				4.45
Easy to start	services published	by someone e	else			4.64
Easy to see w	hat services are a	vailable in the	network			4.64

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Outcomes And Interpretation

- Participants considered service registry useful
- Most considered verified service authorship important
- Several participants were confused by concepts like nodes
 - need to improve UI for a non-technical audience
- Acceptable response time: 10 minutes or less
 - a large minority voted for 10 seconds

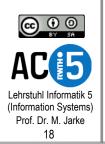


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Technical Evaluation: Requirements

- Block time of < 1s used during evaluation proved infeasible
 - storage requirement too large
 - network synchronization issues
- Further evaluation yielded base storage requirements of
 - 3.7GB per year for 9.3s block time
 - 125MB per year for 271s (4.5min) block time

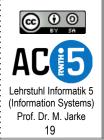
 \rightarrow block times between 10s and 1min are feasible and would fulfill most users' expectations



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Technical Evaluation: Security and Limitations

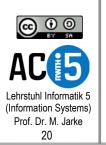
- Any attacker controlling the majority of mining power in the network can censor future transactions (e.g., exclude a particular user)
- Regardless of the blockchain-based registry, disruption of the network is easily possible by attacking the shared storage
- But: "Rewriting history" (e.g., changing ownership of a service) is quite expensive
 - an attacker twice as powerful as the existing network needs exactly one month to rewrite a block that is one month in the past



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Conclusion

- Blockchain-based username and service registry is secure and feasible under realistic conditions
 - evaluation participants found the system useful
 - storage requirements are feasible, if response time requirements are not "real-time"



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Future Work

- Service explorer only a first step
 - personalized recommendations, tagging, and community analysis
- Contributions, in their various forms (providing computing resources, authoring services), should be recognized and rewarded
 - blockchain cryptocurrency may form the basis of a reputation system
 - bounties could be awarded for desired contributions

