Discovering Resources in Large-Scale Grid Distributed Environments

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Tuesday, April 17, 2012
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Outline

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- Depiction of a Grid Distributed Environment
- Resource Discovery in Dynamic Distributed Environments
- Resource Discovery based on Matchmaking
- Resource Discovery in Distributed Environments prone to Resource Failures
- Trust-aware resource Discovery in Distributed Systems

Introduction (1/3)

- Grid is a type of distributed system that enables the sharing, selection, and aggregation of geographically distributed “autonomous” resources dynamically at runtime depending on their availability, capability, performance, cost, and users’ QoS requirements.

- Grid technologies support the sharing and coordinated use of diverse resources in dynamic VOs that is, the creation, from geographically and organizationally distributed components, of virtual computing systems that are sufficiently integrated to deliver desired QoS.

- The shared resources in a Grid infrastructure could vary from networks, clusters of computers, memory space or storage capacity, computational power (CPU time or CPU cycles), data repositories, files, attached peripheral devices, sensors, software applications, online instruments and data, all connected usually through the Internet and a middleware software layer that provides basic services for security, monitoring, resource management, etc

Introduction (2/3)

- The question is what happens when a remote application or a remote user requests access to a remote resource either to execute a job or to have access in the resource’s data?

- A mechanism provided by the distributed infrastructure should be able to discover an appropriate resource for a request.

- Discovering resources in traditional computing environments is relatively easy because the number of shared resources is small and all resources are under central control.

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Introduction (3/3)

- In a Grid system there are certain factors that make the resource discovery problem difficult to solve.

- Some of these factors are: the huge number of resources, the heterogeneity of resources, and the uncertainties met in such systems.

- In our previous efforts, we have dealt with the discovery of resources, taking into consideration certain particularities of distributed systems, such as:

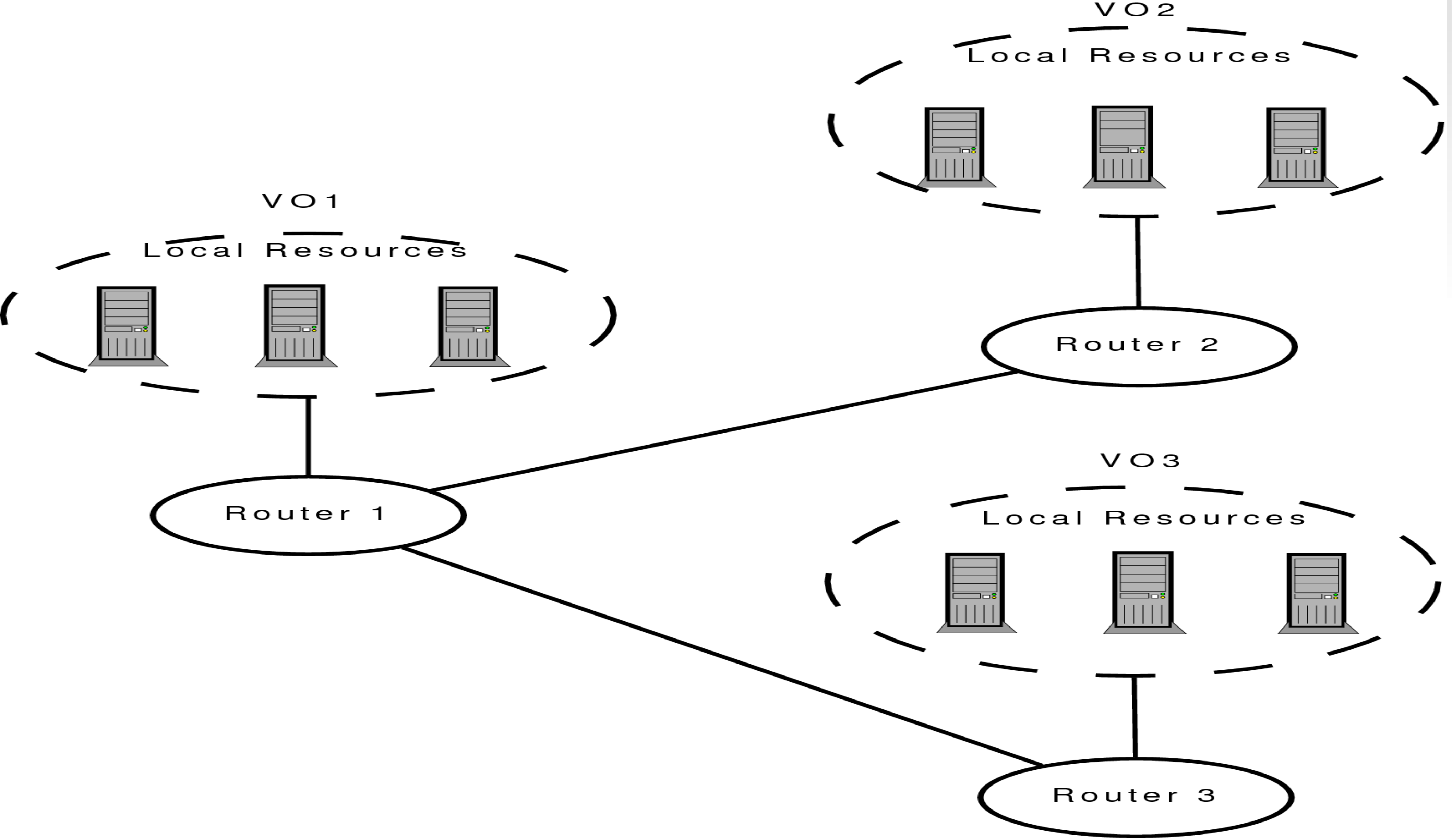
Dynamicity

Heterogeneity

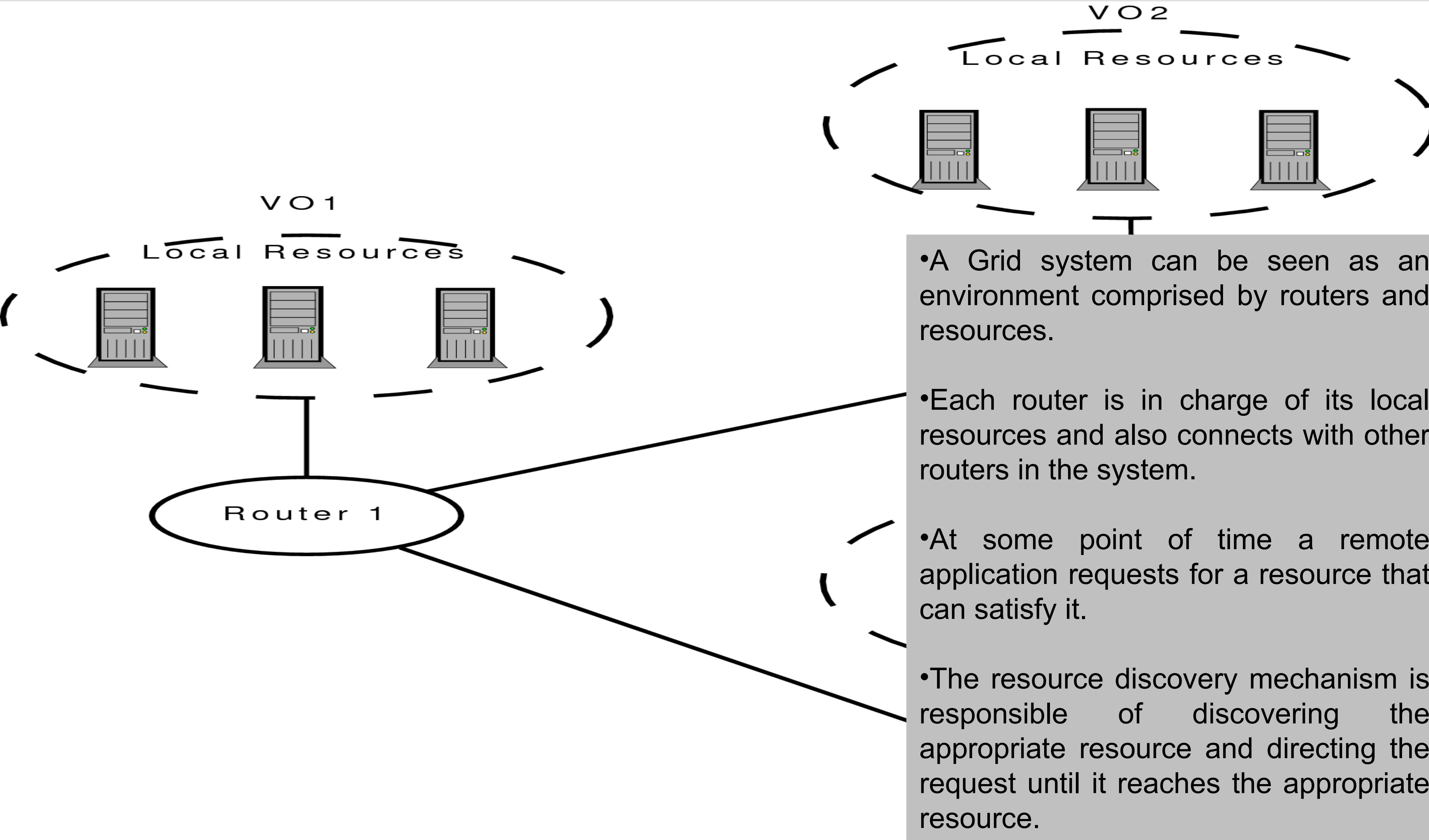
Resource Failures

Trust

Depiction of a Grid Distributed Environment



Depiction of a Grid Distributed Environment



•A Grid system can be seen as an environment comprised by routers and resources.

•Each router is in charge of its local resources and also connects with other routers in the system.

•At some point of time a remote application requests for a resource that can satisfy it.

•The resource discovery mechanism is responsible of discovering the appropriate resource and directing the request until it reaches the appropriate resource.

Resource Discovery in Dynamic Distributed Environments

- A Grid system is characterized by resources that can get in an offline state at any time.
- The reason that causes this dynamic behaviour is mainly the distributed ownership. (a) An owner may establish a policy on a workstation that states that a foreign job can be run on a machine only at certain periods of time. (b) An owner may establish a policy on a workstation that states that a foreign job can be run on a machine when the local load is under a certain limit. When the local load reaches that limit, a resource must exit the system and execute local jobs only.
- An effective resource discovery mechanism should be able to overcome the dynamic nature of such a system.
- A mechanism, previously proposed, uses Routing Tables in order to efficiently direct requests to the appropriate resources. The problem is that the Routing Tables mechanism assumes that all resources are permanently online.
- We have enhanced the Routing Tables mechanism with an updating procedure, in order to cover the cases of offline resource events, bound to occur in any Grid distributed environment.

Resource Discovery with a Matchmaking Mechanism (1/2)

- A Grid system is composed of heterogeneous networked resources with different technical characteristics.
- When an application requests a resource of specific technical characteristics, an efficient resource discovery mechanism should be able to direct this request to the most suitable request.
- We have enhanced the routers of the distributed system with matchmaking capabilities. Taking into consideration the limited computing capabilities routers have, we kept the matchmaking framework clean and simple.

Resource Discovery with a Matchmaking Mechanism (2/2)

Architecture: Intel
Operating System: Solaris26
Minimum Disk: 35000
Minimum Memory: 512

Resource Type 1
Architecture: Intel
Operating System: Linux
Available Disk: 20000
Available Memory: 128

Resource Type 2
Architecture: SGI
Operating System: Irix6
Available Disk: 40000
Available Memory: 1024

Resource Type 3
Architecture: Intel
Operating System: Solaris26
Available Disk: 40000
Available Memory: 1024

Resource Type 4
Architecture: Intel
Operating System: Solaris26
Available Disk: 35000
Available Memory: 512

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Matchmaking Rules

- The architecture and operating system characteristics of the request must match the architecture and operating system characteristics of the resource.
- The minimum disk size required by the request must be smaller or equal to the available disk size of the resource.
- The minimum memory space required by the request must be smaller or equal to the available memory space of the resource.

Resource Discovery in Distributed Environments prone to Resource Failures

- Due to the huge number of resources in a Grid system, the probability of resource failures is increased.
- Resource failures are unpredictable and common due to hardware faults, software faults or power outages.
- Combining the matchmaking and the dynamic approaches (discussed previously), we have proposed a resource discovery scheme that can guarantee discovering the most suitable resource and then directing an application’s request to the appropriate resource in the distributed environment, where resource failures are a common fact.
- Moreover the proposed scheme deals with the phenomenon of consecutive resource failures.

Trust-aware resource discovery in Distributed Systems (1/5)

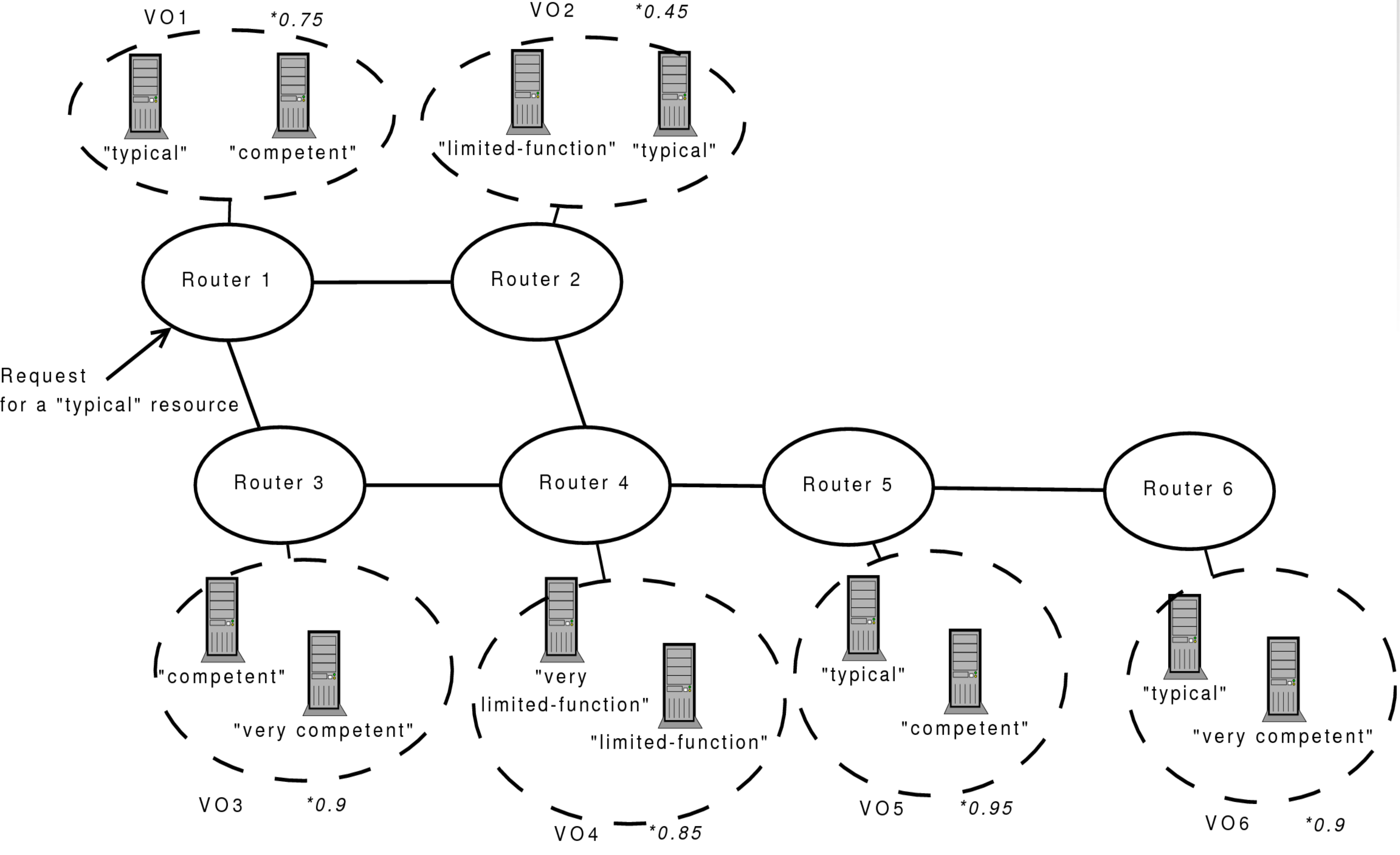
- Suppose a resource provider P is part of a Grid system and is capable of satisfying the request from a resource requestor R. The issues that should be considered in this communication are to protect the local data in P from a malicious attack caused by the components of the request, and to ensure the integrity and secrecy of the request. Since successful transactions in a distributed system are crucial for the integrity of the whole system, it would be beneficiary to direct requests only to trustworthy resource providers. This will significantly decrease the possibility of endangering the integrity of the system.

- There are mechanisms capable of dealing with the above implications in resource-sharing environments like sand-boxing, encryption and other access control and authentication techniques. These mechanisms, however, incur additional overhead. Incorporation of the trust factor into the resource discovery decisions could significantly enhance the integrity of the system and also minimize the additional overhead. A resource discovery mechanism, aware of the trust relationship between resource providers and resource requestors, can perform the directing procedure of the requests in a way that the possibility of unwanted implications can be minimized.

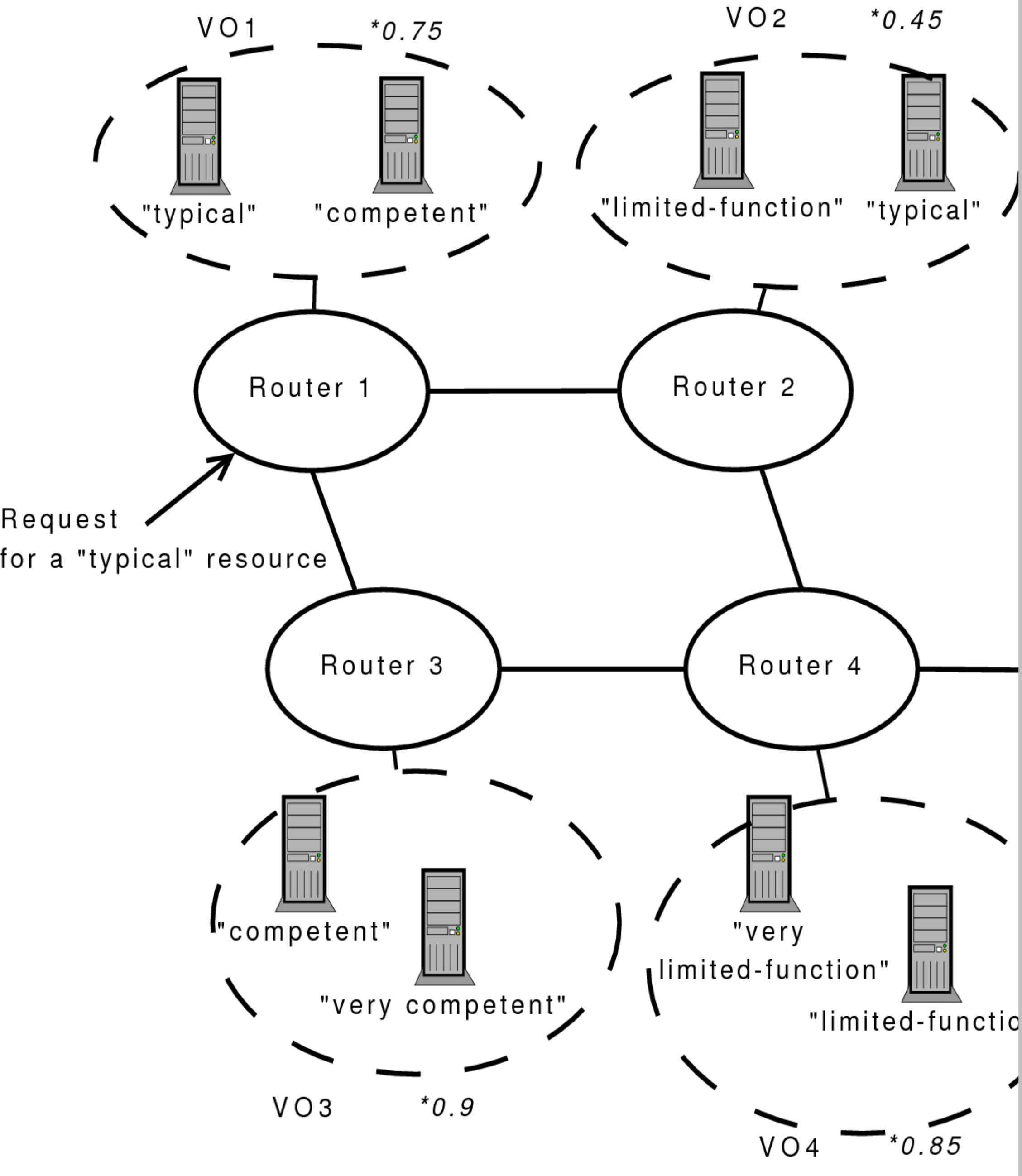
Trust-aware resource discovery in Distributed Systems (2/5)

- We have introduced the concept of global trust values for all Grid nodes. Based on the availability of these values, we have proposed a trust-aware resource discovery mechanism that can effectively direct requests created in the distributed system to trustworthy resource providers. Moreover, the trust-aware resource discovery mechanism manages effectively the cases of dynamic changes in the trustworthiness of the nodes in order to maintain the directing of requests up-to-date.

Trust-aware Resource Discovery in Distributed Systems (3/5)



Trust-aware Resource Discovery in Distributed Systems (3/5)



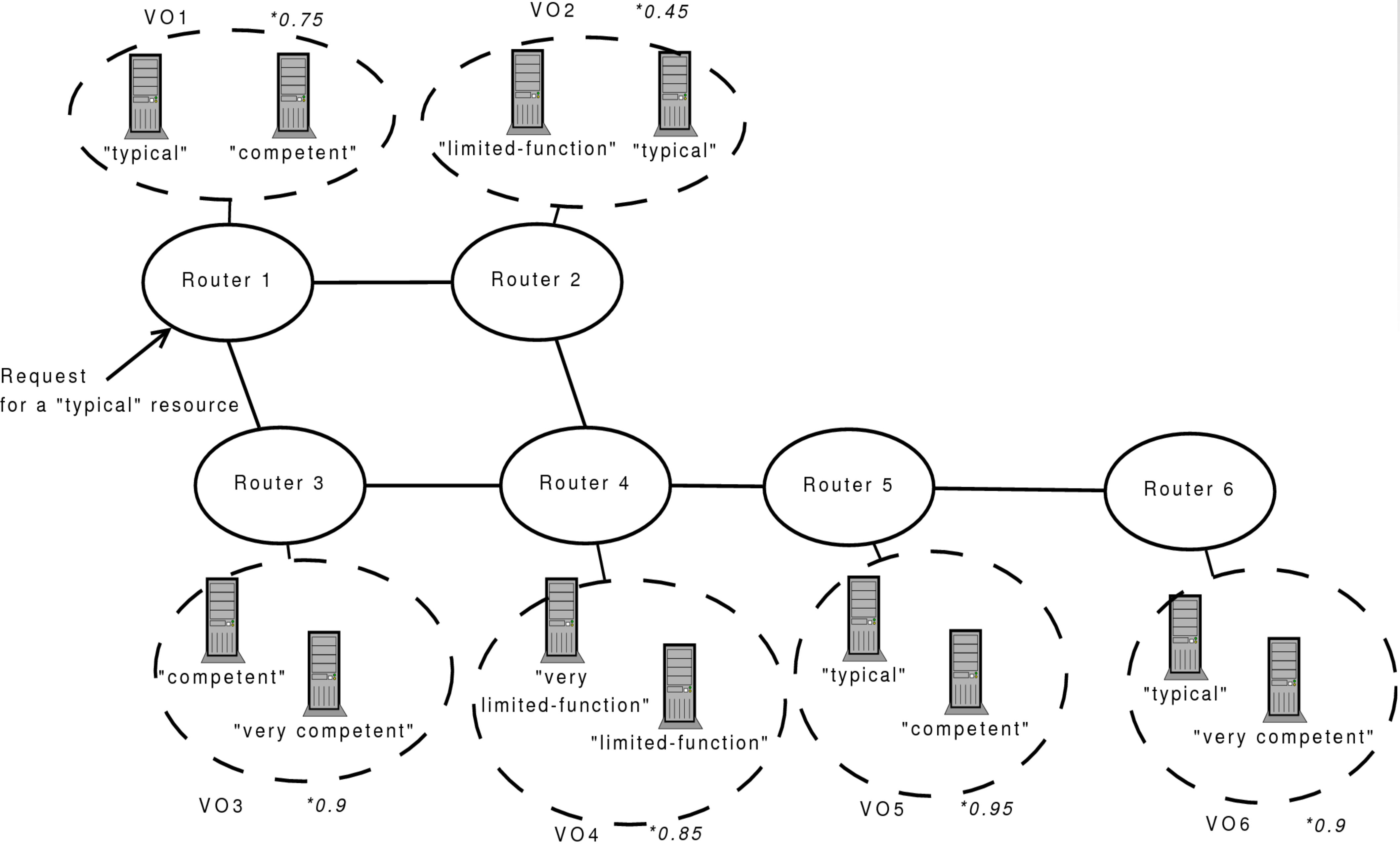
•The proposed mechanism uses simple matchmaking rules in order to identify each resource as part of a certain technical category. Resources that are available in the system use descriptions of their technical characteristics regarding their available disk size and available memory.

•The categorization of a resource is one of the following: “very limited-function”, “limited-function”, “typical”, “competent”, and “very competent”. It is totally adjustable and easily expandable in order to provide categorizations for a wider range of available resources or to depict more than five technical categories.

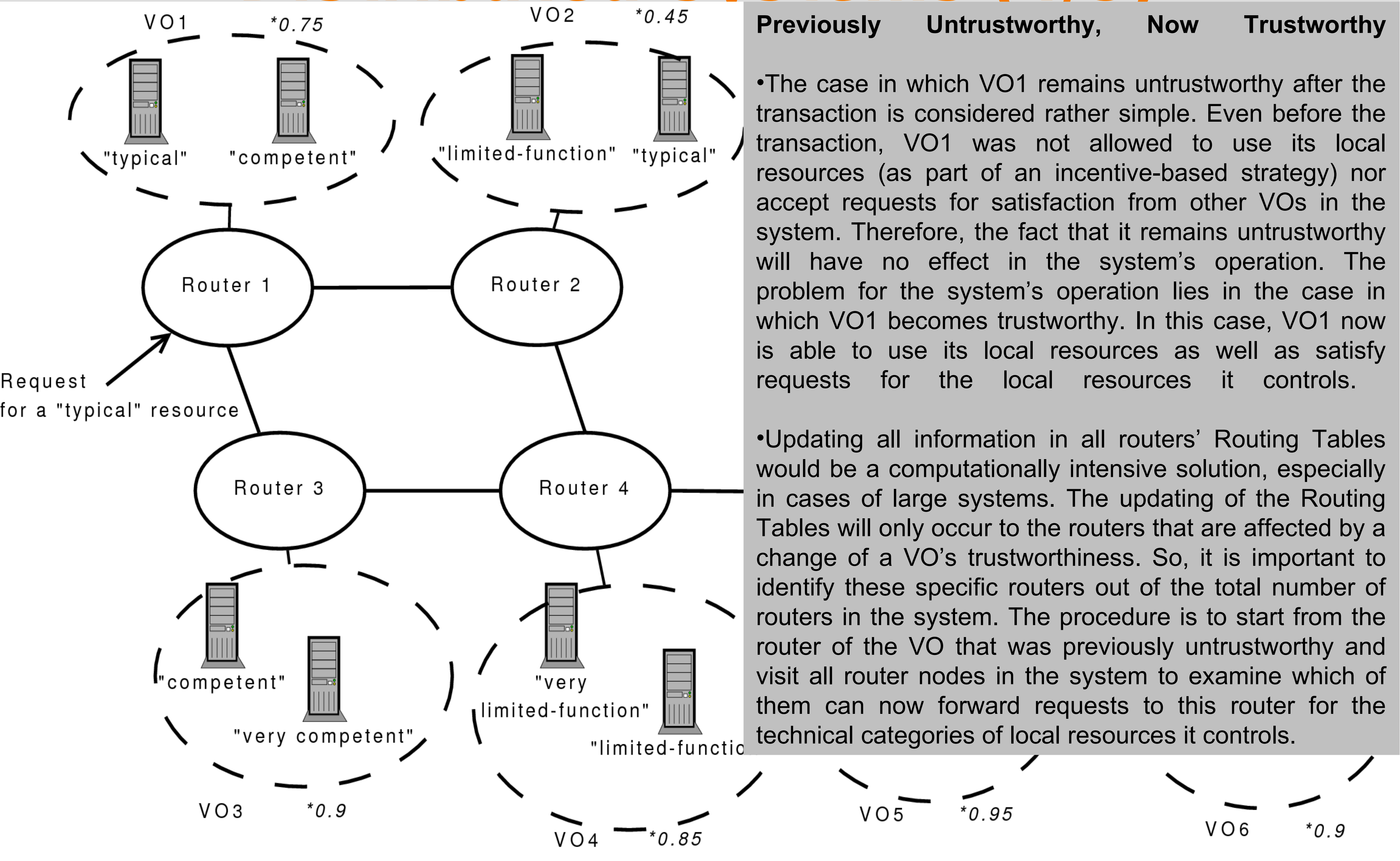
•Each router maintains the distances to a minimum number of five resources, one of each technical category, satisfying the range of possible requests in the system. This procedure prevents the size of the Routing Tables to become extremely large, and supports the scalability of the mechanism when new-joined resources wish to enter the system and acquire the information available in the Tables.

•The Routing Tables only maintain information about the distances to resources, controlled by trustworthy VOs. VOs that have a trust value higher than a pre-defined threshold value, are considered trustworthy and can satisfy requests.

Trust-aware Resource Discovery in Distributed Systems (4/5)



Trust-aware Resource Discovery in Distributed Systems (4/5)

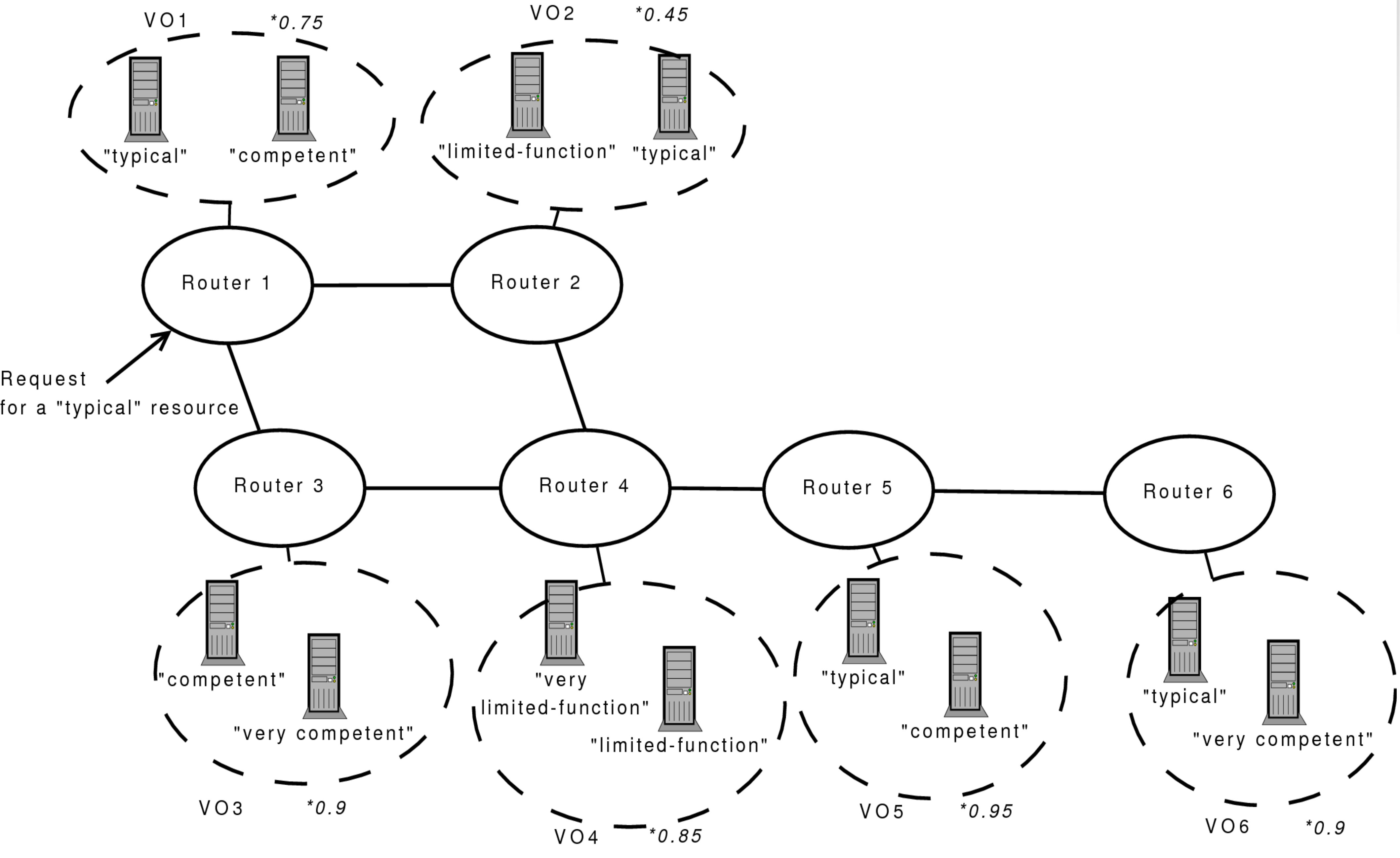


Previously Untrustworthy, Now Trustworthy

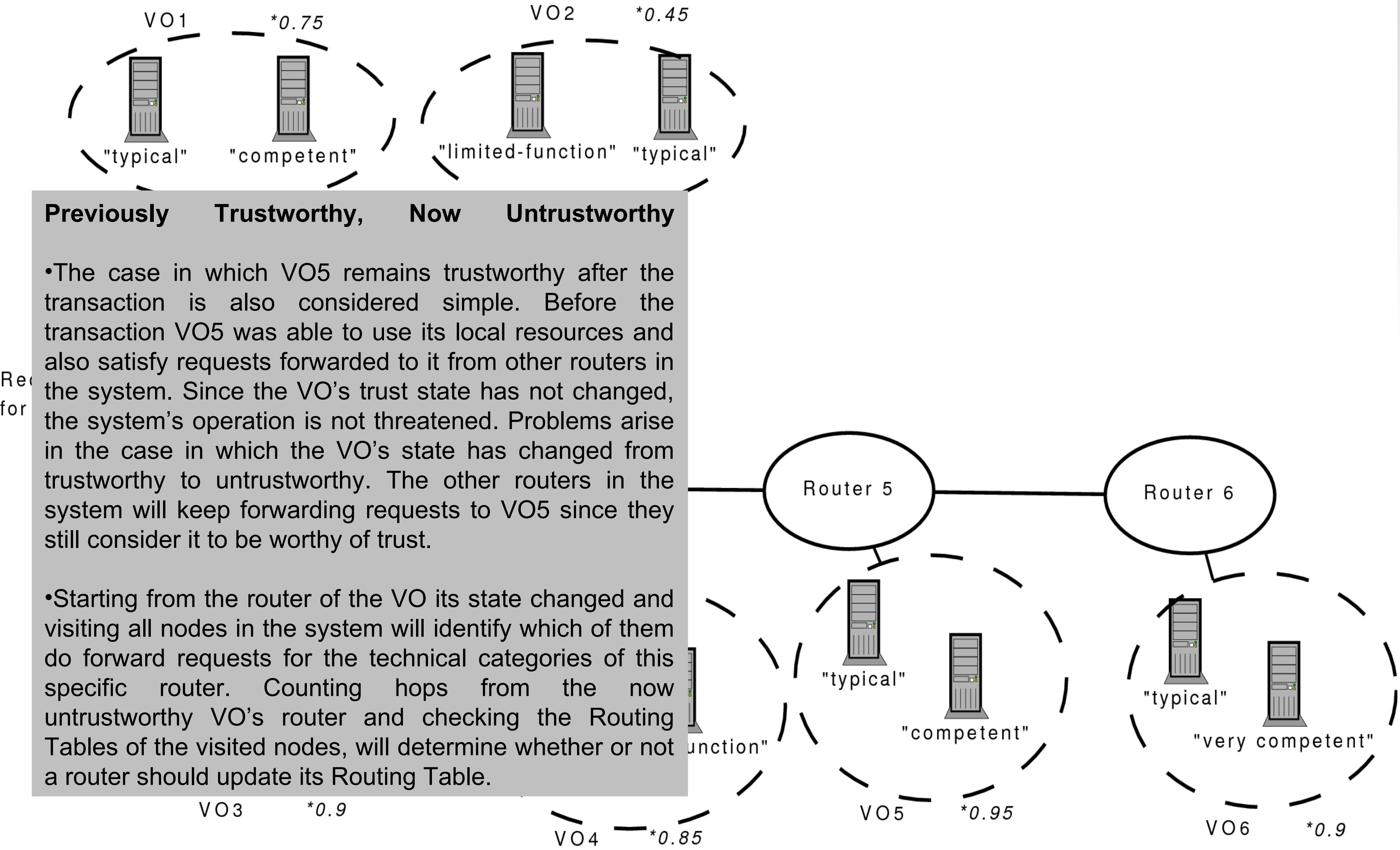
•The case in which VO1 remains untrustworthy after the transaction is considered rather simple. Even before the transaction, VO1 was not allowed to use its local resources (as part of an incentive-based strategy) nor accept requests for satisfaction from other VOs in the system. Therefore, the fact that it remains untrustworthy will have no effect in the system's operation. The problem for the system's operation lies in the case in which VO1 becomes trustworthy. In this case, VO1 now is able to use its local resources as well as satisfy requests for the local resources it controls.

•Updating all information in all routers' Routing Tables would be a computationally intensive solution, especially in cases of large systems. The updating of the Routing Tables will only occur to the routers that are affected by a change of a VO's trustworthiness. So, it is important to identify these specific routers out of the total number of routers in the system. The procedure is to start from the router of the VO that was previously untrustworthy and visit all router nodes in the system to examine which of them can now forward requests to this router for the technical categories of local resources it controls.

Trust-aware Resource Discovery in Distributed Systems (5/5)



Trust-aware Resource Discovery in Distributed Systems (5/5)



Previously Trustworthy, Now Untrustworthy

•The case in which VO5 remains trustworthy after the transaction is also considered simple. Before the transaction VO5 was able to use its local resources and also satisfy requests forwarded to it from other routers in the system. Since the VO's trust state has not changed, the system's operation is not threatened. Problems arise in the case in which the VO's state has changed from trustworthy to untrustworthy. The other routers in the system will keep forwarding requests to VO5 since they still consider it to be worthy of trust.

•Starting from the router of the VO its state changed and visiting all nodes in the system will identify which of them do forward requests for the technical categories of this specific router. Counting hops from the now untrustworthy VO's router and checking the Routing Tables of the visited nodes, will determine whether or not a router should update its Routing Table.

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Thank you!

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