Understanding Resource-aware Control of Media-centric Service Composition over Future Internet Testbeds

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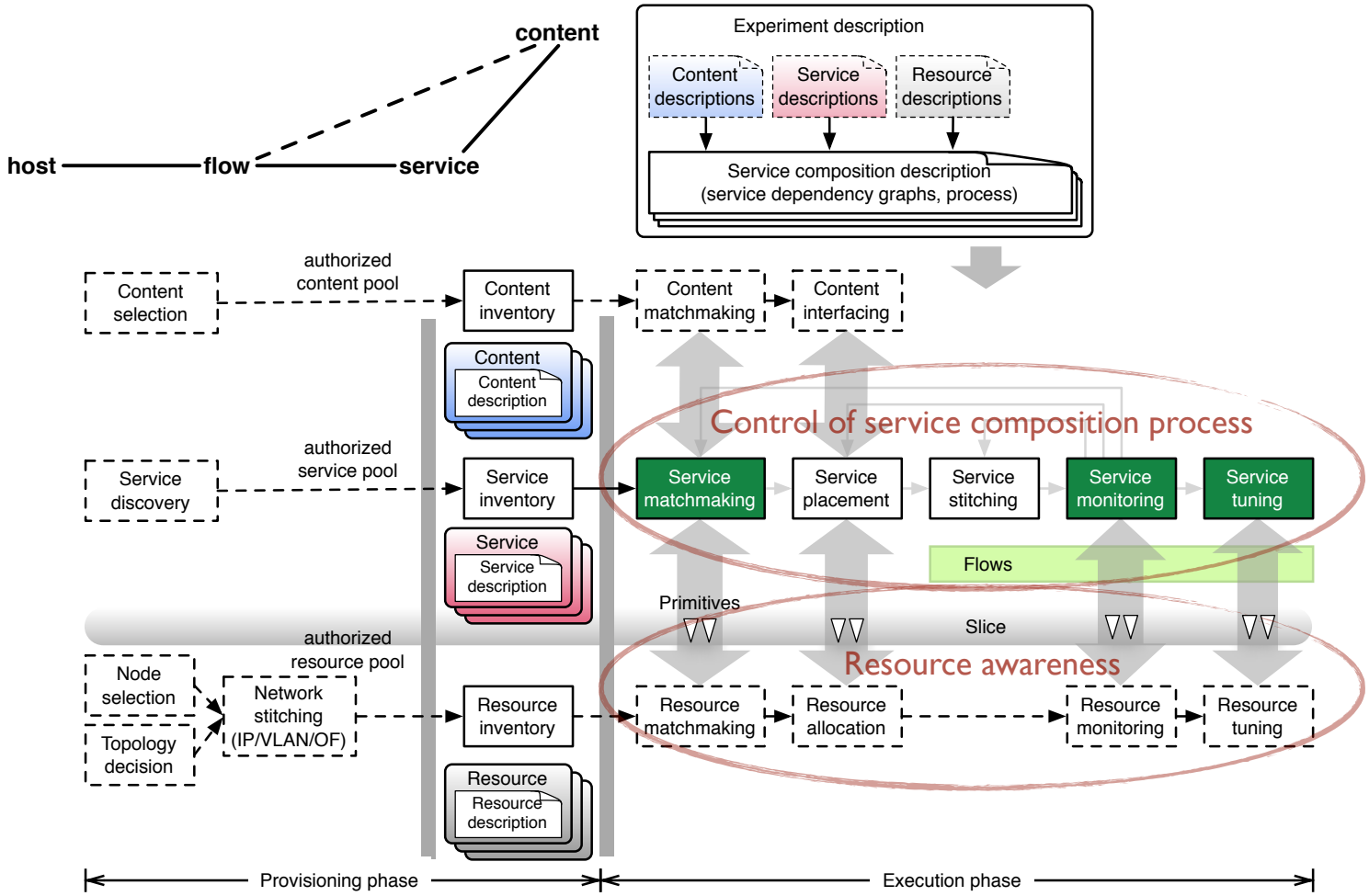
Sang Woo Han, JongWon Kim
{swhan, jongwon}@nm.gist.ac.kr

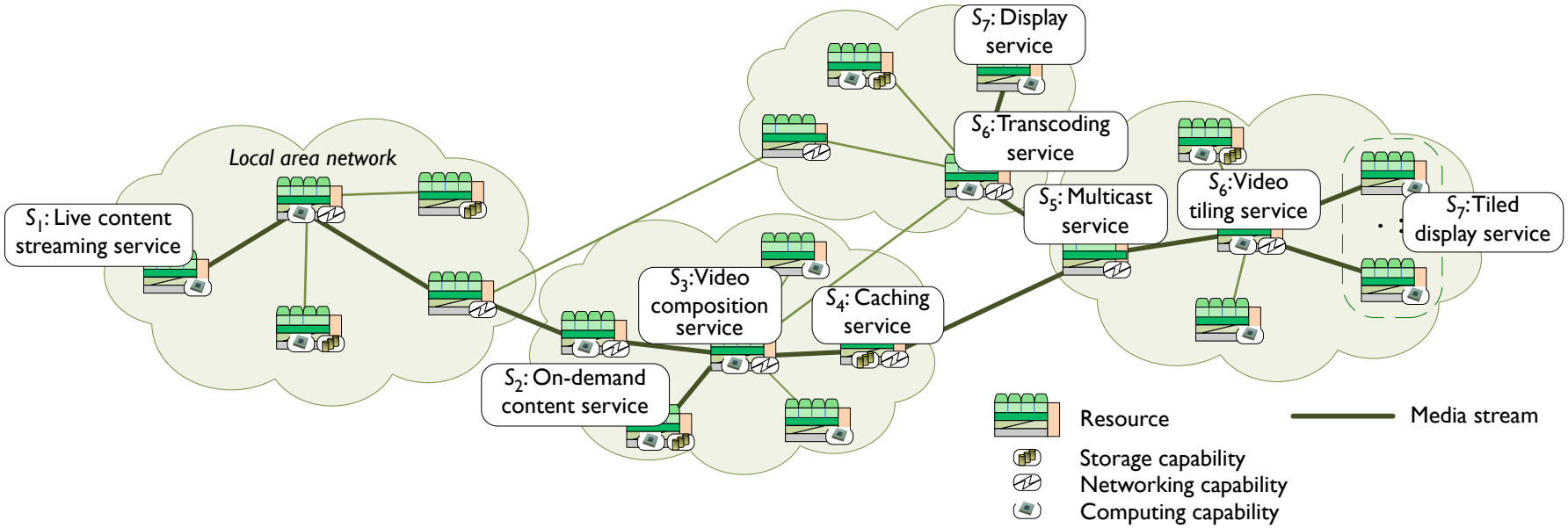
Networked Computing Systems Lab.,
School of Information and Communications,
GIST (Gwangju Institute of Science and Technology), KOREA

Resource-aware media-centric service composition over Future Internet

- Resource-aware control of each step in the service composition process in interaction with resources
- Monitoring and management services that assist in handling of versatile (i.e., virtualized and programmable) computing/networking resources



Media-centric service composition over Future Internet testbeds

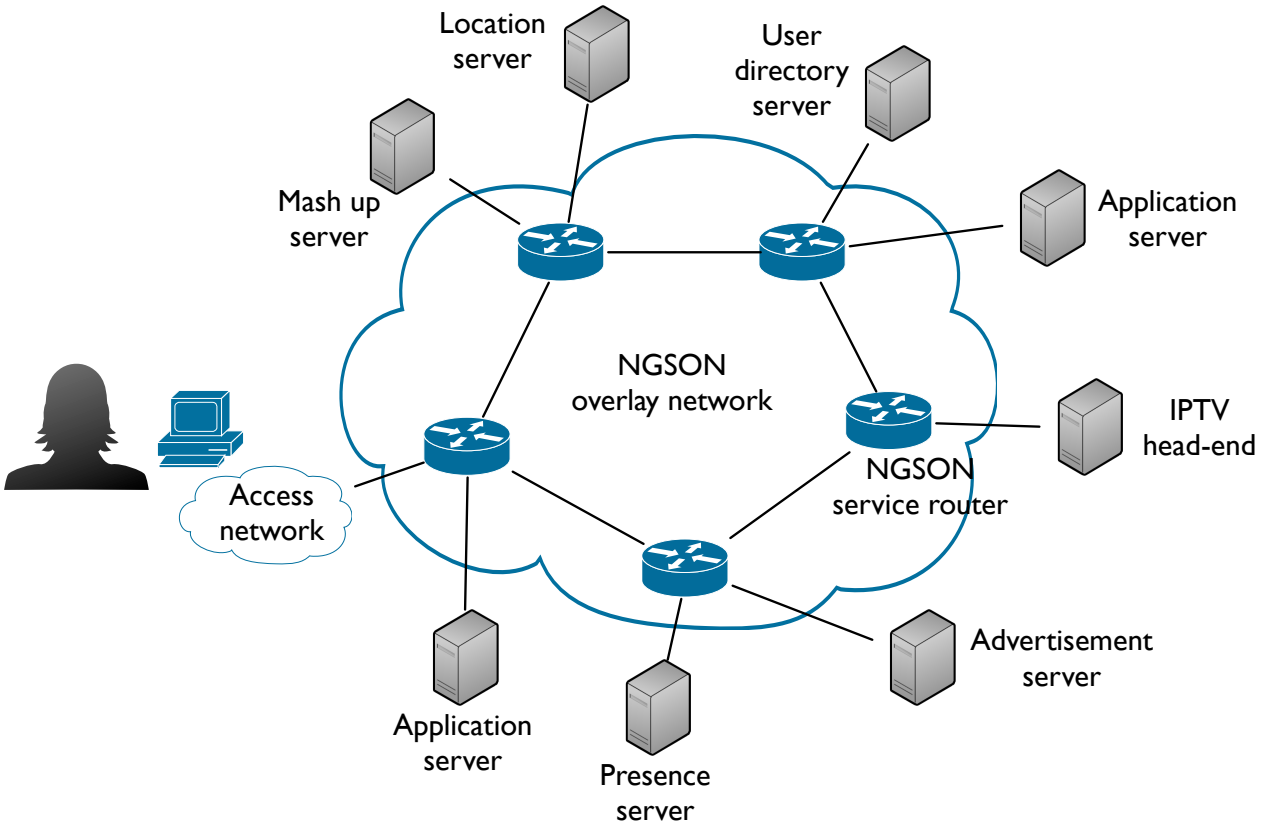


Motivation

- Experimenters desire to create an assemble of composable services, optimized in efficiently utilizing (virtualized/programmable) computing/ networking resources, where multiple media-centric (i.e., retrieval, transcoding, display services) services are stitched via control and data dependencies.
- One of the major problems with current media-centric service composition is that one has to plan the relationship among media services without sufficient consideration on underlying infrastructure.
- This problem makes it difficult to maintain media-centric service composition within an acceptable quality range, especially given fluctuations in resource availability and load.
- Existing Web service composition solutions provide little help in this regards.
- We need a better approach for **RESOURCE-AWARE** service composition, which gives knowledge about the relationship between the amount of resources and the quality of service composition and then guidance of adaptation behaviors in intelligent ways.

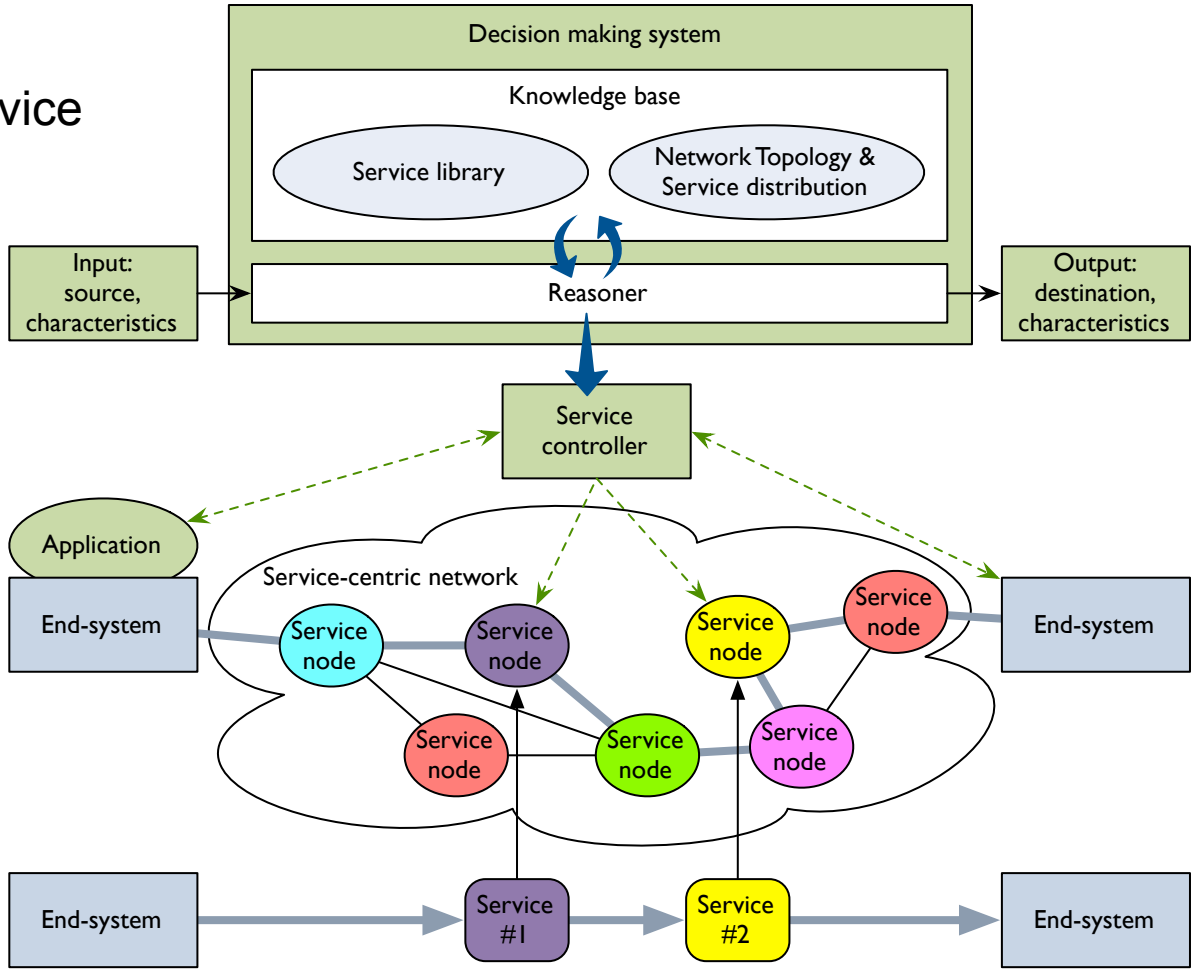
NGSON (*c.f.*, Smart Network)

- NGSON provides service composition on overlay networks
  - End users and service nodes join and leave SON via service routers
  - Creating network paths are independent the type of networks (e.g., IMS, 3G, WiMAX)
  - Service-aware network paths are established with considering physical network status
  - P4P, IETF ALTO (Application-Layer Traffic Optimization)



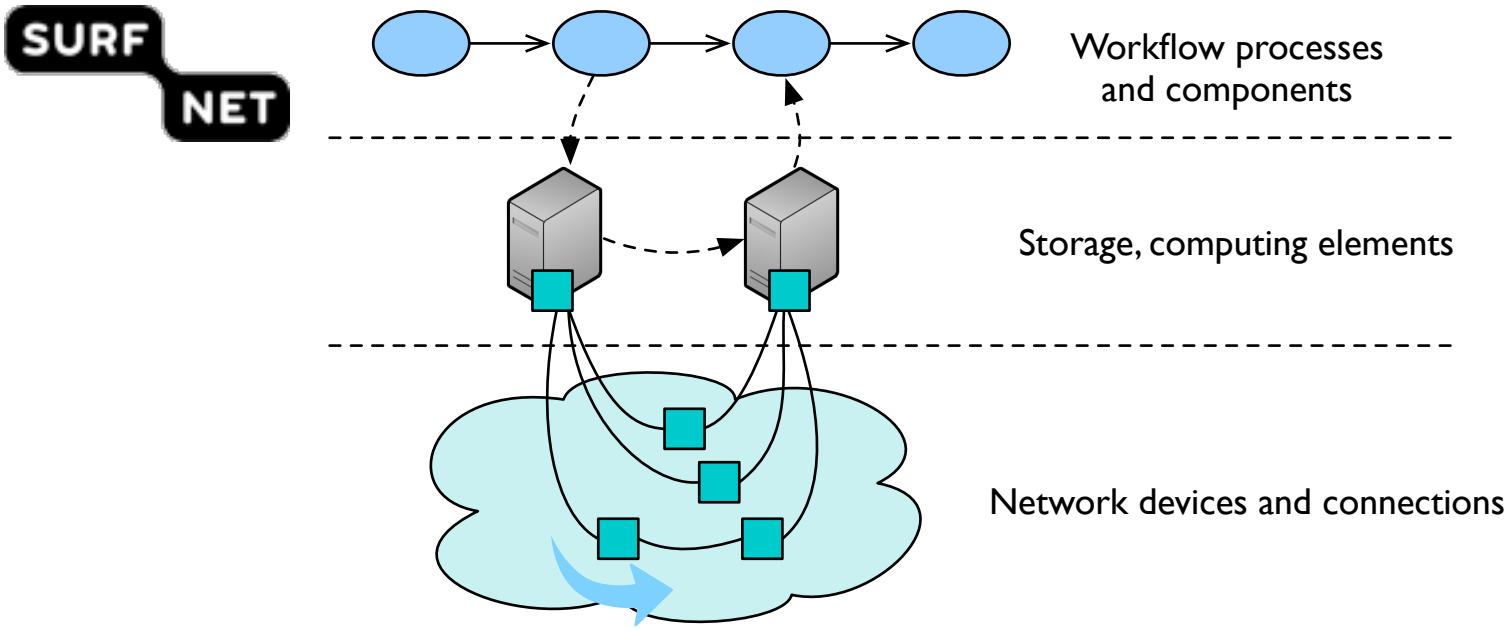
X. Huang, S. Shanbhag, and T. Wolf, "Automated Service Composition and Routing in Networks with Data-Path Services," in Proc. of ICCCN 2010

- In-network processing
- I/O parameter based service composition
- Performance indices
  - Link delay
  - Service processing delay



Z. Zhao, P. Grosso, R. Koning, J. van der Ham, C. de Laat, "Network resource selection for data transfer processes in scientific workflows," in Proc. of WS. on Workflows in Support of Large-Scale Science 2010

- Semantic description
  - NDL (network description language) + CDL (CineGrid description language)
- Finds the optimal paths for digital media streaming



Proposed approach

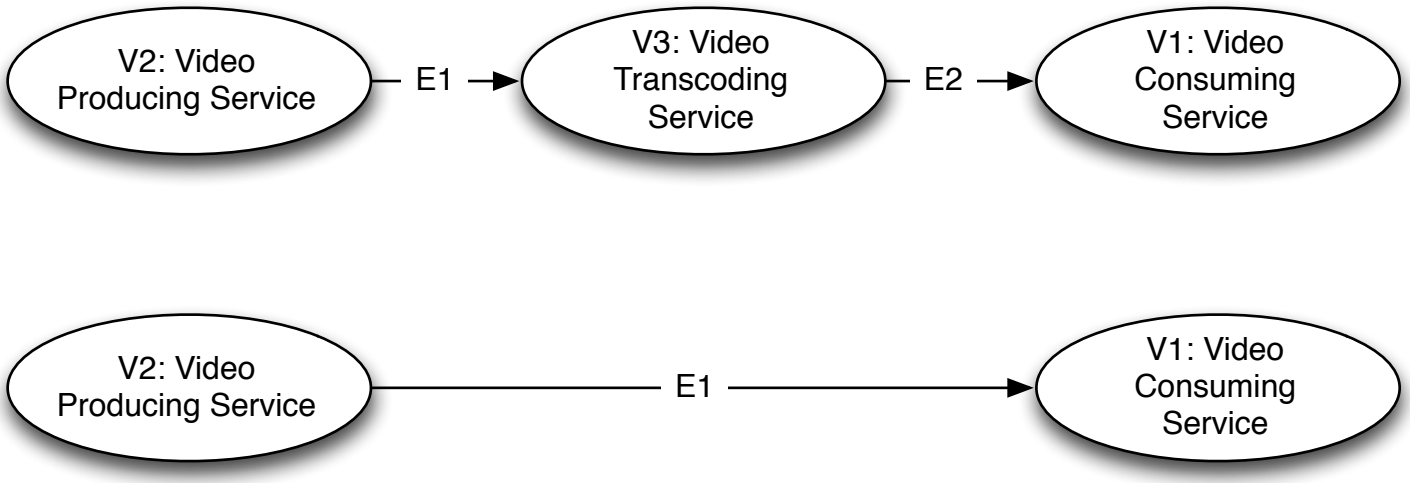
- Describe key elements to clearly represent the resource-aware and media-centric service composition
- Define a workflow-style service composition process for maintaining resource-aware media-centric service composition within an acceptable operating range
- Has not practically verified and validated yet

Key element: Resource, Service, Content

- Resource
  - Node is a resource container that supports computation and networking resource capabilities via virtualization
  - Resource capability provides specific resource capabilities, characterized by its type and amount, that is a set of resources virtualized from dispersed nodes. It is exposed as an interface that is understandable by a service
- Service
  - has input and output interfaces and functions
  - needs resource primitive to obtain the desired resources
- Content
  - pre-stored or live media
  - has an unique name and a format

Key element: Service dependency graph

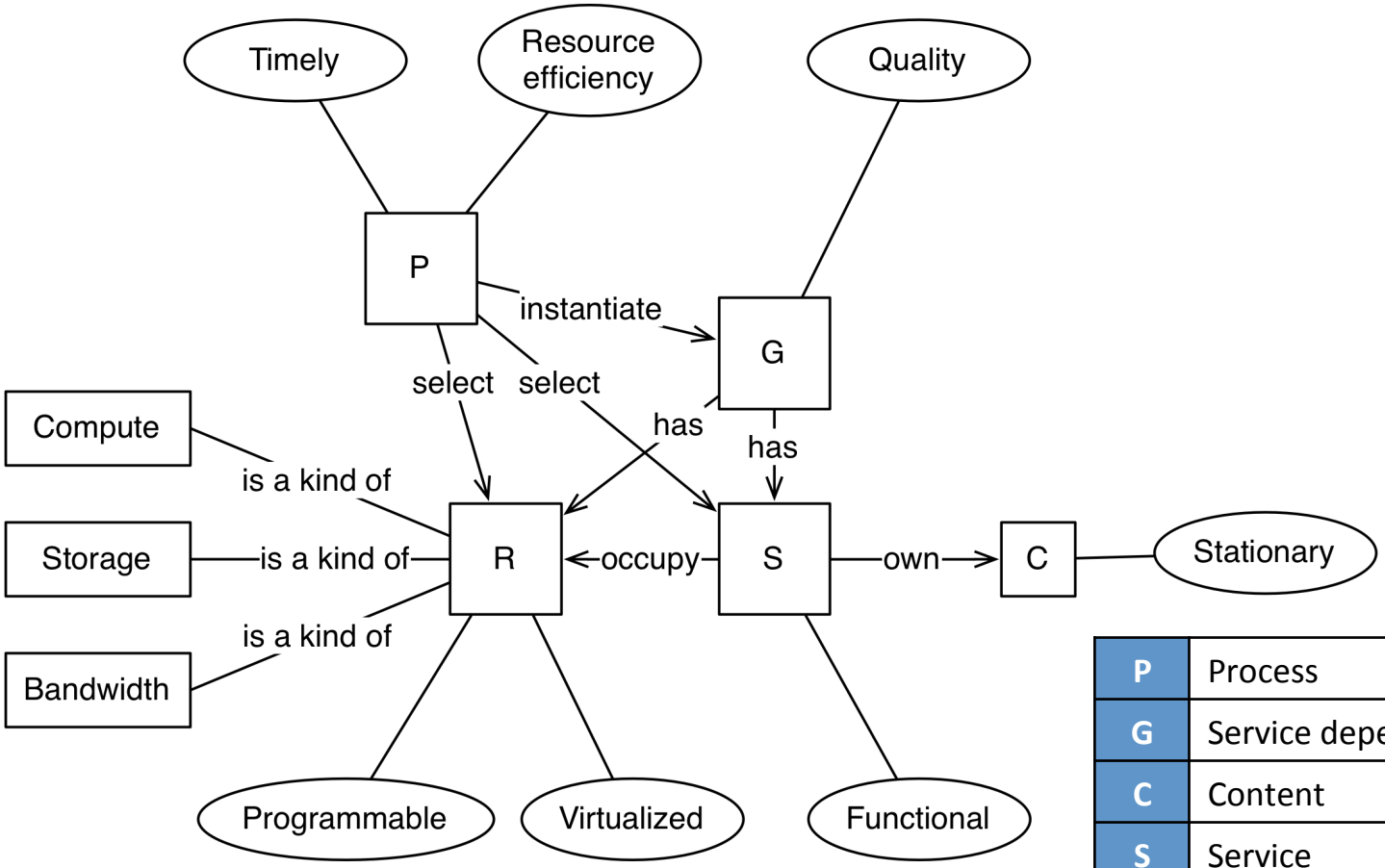
- The service dependency graph describes service composition (i.e., a chain of service instances) by representing the relationship between services



Key element: Process

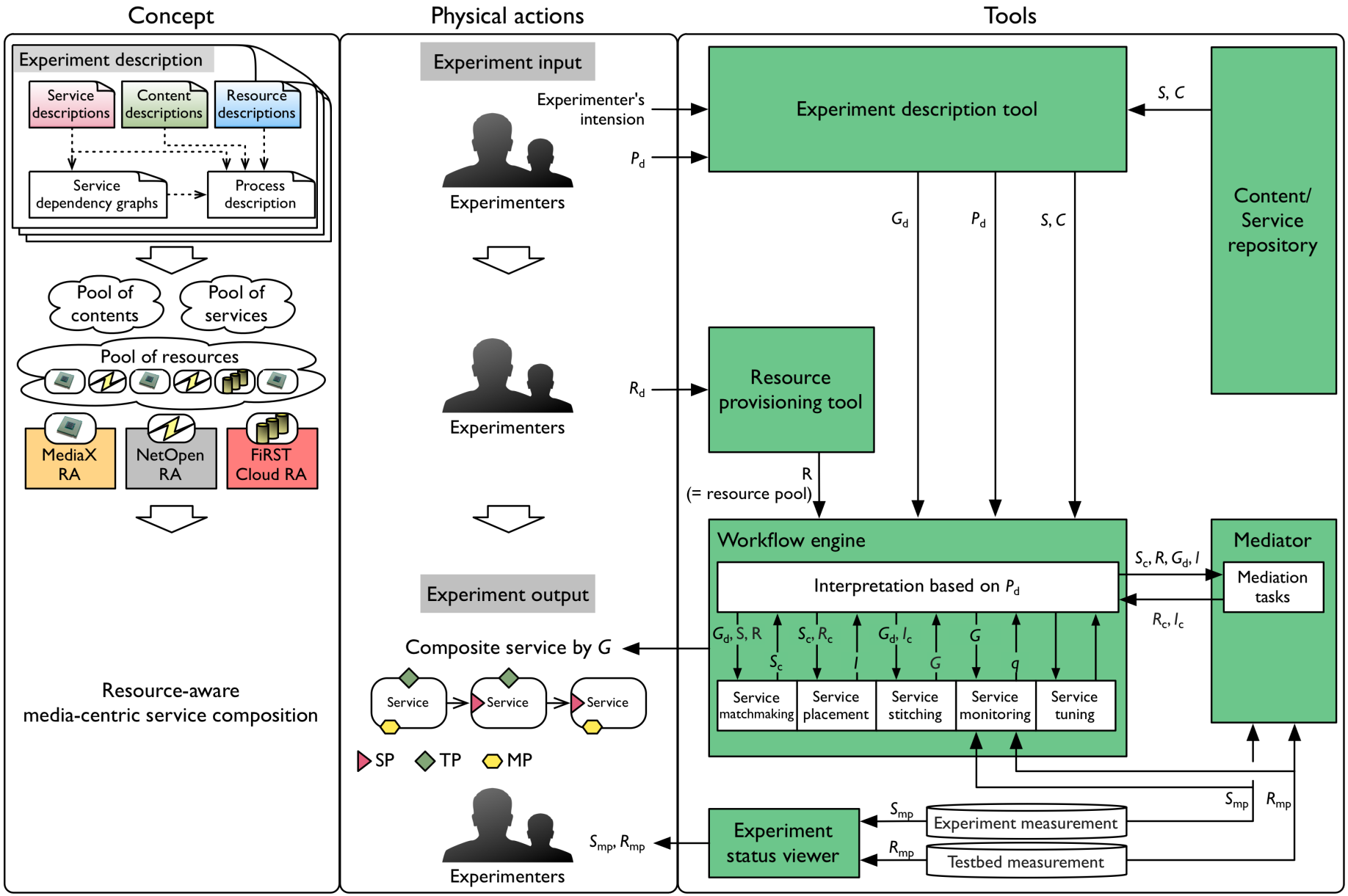
- Service matchmaking P_{mm}
  - looking for candidate services that meet the requirements of services included in a given service dependency graph
- Service placement P_{pl}
  - loading code of the candidate services, stored in repositories, on the chosen set of resources and creating service instances via execution
- Service stitching P_{st}
  - actually binding service instances according to the service dependency graph
- Service monitoring P_{mon}
  - observing measurement values from service instances and checking whether service composition is keep going well or not
- Service tuning P_{tune}
  - individually adjusting preset control parameters in order to remove performance bottlenecks of individual services and resources

An entity relationship diagram of key elements for resource-aware service composition



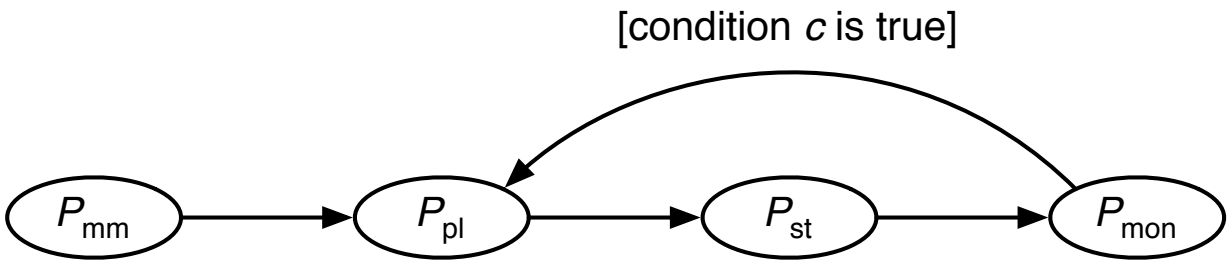
P	Process
G	Service dependency graph
C	Content
S	Service
R	Resource

A conceptual illustration on resource-aware service composition experiments



Design phase

e.g., An experiment description for HD video delivery & presence

Content Set $C^{(des)}$	Full HD live videos c_1, c_2, c_3
Service Set $S^{(des)}$	DXT producing services s_{vp}^{c1}, s_{vp}^{c2}, s_{vp}^{c3} Networking service s_{net} Networked display service s_{dp}
Resource Set $R^{(des)}$	Media servers dxt01.gist, dxt02.gist, dxt01.cnu, dxt01.khu Networking resource of.gist Networked display resource disp.gist
Service dependency Graph G	
Process P	

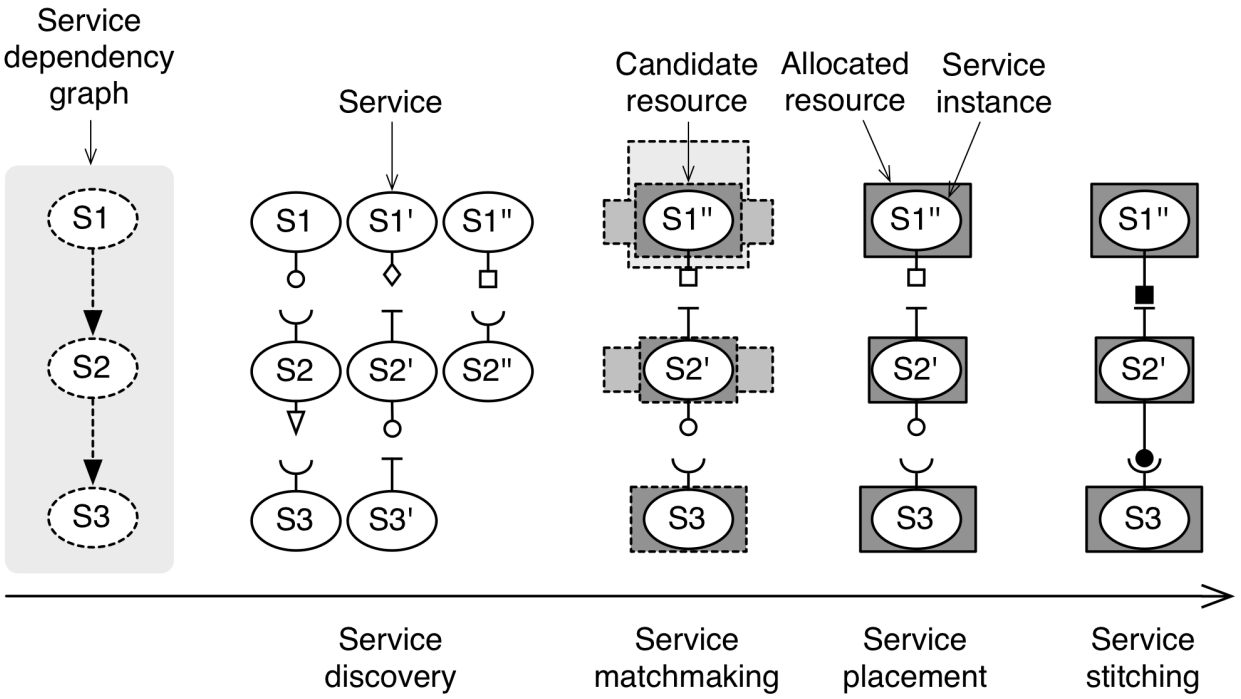
Provisioning phase

- For given C_d, S_d, R_d, an experimenter gets the authority to legally use C, S, R
  - Set of desired contents C_d, Set of desired services S_d, Set of desired resources R_d
  - Pool of contents C, Pool of services S, Pool of resources R

- Based on the resource description R_d and the network topology, a network-stitched resource pool R is provided by establishing physical network paths over the authorized resources.

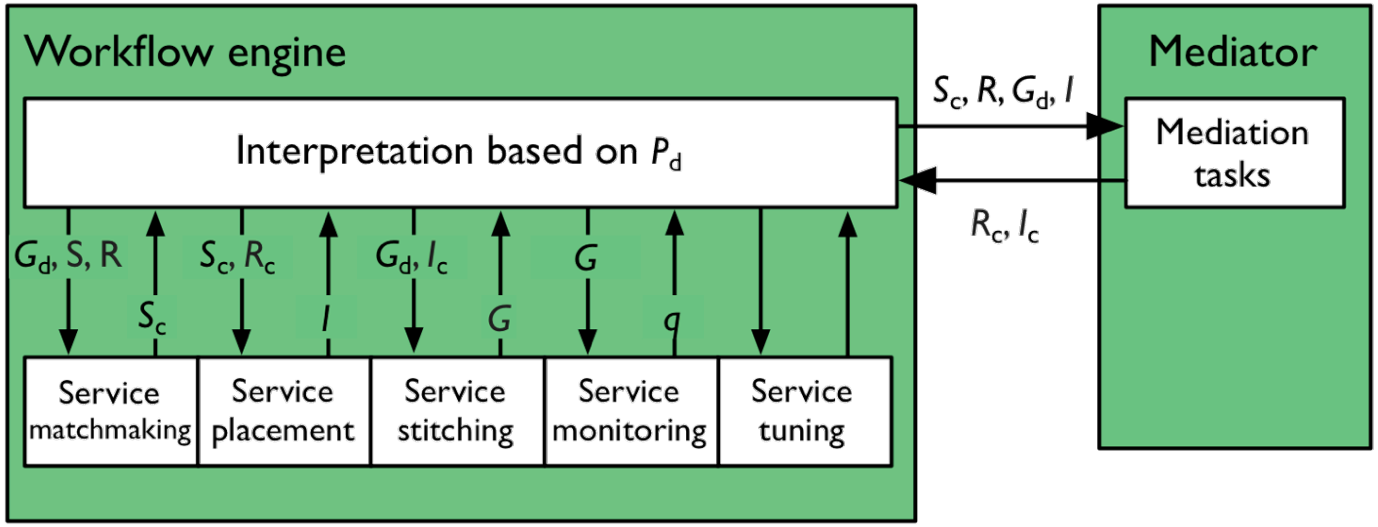
Execution phase

- Service composition conducted by interpretation based on P_d
  - Input: C, S, R, G_d
    - Desired service dependency Graph G_d, Desired process P_d
  - Process: conduct service composition following given Process P_d
  - Output: Composite service CS



Resource-efficient service composition by mediator

- The mediator assists the interpretation box in conducting resource-efficient service composition
  - For given S, R, G_d, the mediator recommends a matching, named as candidate Service Instance I_c, that matches services and resources
  - At this stage, we define a tentative problem on resource-efficient service composition problem, but remain any mediation algorithms to solve the problem as future work



A tentative resource-efficient media-centric service composition problem

- Assumption
  - Experimenters do not know the exact amount and type of resources services need
- Problem
  - For given S, R
  - Find an efficient matching between S and R so that $q(S, R)$, objective function to represent resource efficiency, comes close to 1
    - If $q(S, R)$ is 1, than it is ideal case! (the most efficient utilization)
    - If $q(S, R)$ is 0, than resources are overprovisioned

$$q(S,R) = \prod_{S_i \in S} q(S_i, R)$$

$$= \prod_{S_i \in S} \left(\alpha \frac{r^{(com)}(S_i)}{R_i^{(com)}} + (1-\alpha) \frac{r^{(bw)}(S_i)}{R_i^{(net)}} \right)$$

- Notation
  - $r^{(com)}(S_i)$, $r^{(bw)}(S_i)$: the amount of computation and bandwidth resources consumed by S_i
  - $R_i^{(com)}$, $R_i^{(net)}$: the amount of computation and network resources allocated for S_i
  - α: a real value [0, 1]

Service Matchmaking

$$S_c = P_{mm}(G_d, S, R)$$

- Task P_{mm} looks for a syntactically compatible Set S_c of candidate services among services of Set S.
- Syntactical compatibility is established when the name of service is the same as the service name specified in G_d.
- It also checks whether a subset of given Set R can support resource types that Set S_c of candidate services demands.

Service Placement

$$I = P_{pl}(S_c, R_c)$$

- Based on Set S_c of candidate services as the service matchmaking result, Task P_{pl} places Set S_c of candidate services on the chosen Set R_c of physical resources.
- Task P_{pl} launches the candidate services and creates service instances.
- At this stage, Set I of service instances are ready to run individually without interacting with the other service instances.

Mediation for Service Placement

$$R_c = M_{pl}(S_c, R, R_{mp})$$

- Choosing Set R_c is important because the matching between candidate service Set S_c and candidate resource Set R_c becomes crucial on the resource efficiency of service composition.
- So the experimenters can get any help with the mediator that automatically selects Set R_c (if possible, by considering resource availability R_{mp}).

Service Stitching

$$G = P_{st}(G_d, I_c)$$

- Task P_{st} actually binds the stitching points of the chosen Set I_c of service instances to ones of their neighboring service instances.
  - Flows gets generated by service stitching
- Both service instances to be stitched know the addresses of their counter service instances and establish direct connections between them.
- $G = \{(i_a, i_b) | i_a \in I_c, i_b \in I_c\}$ is a graph representing the relation on service instances as the result of service composition.

Mediation for Service Stitching

$$I_c = M_{st}(G_d, I, I_{mp}, R_{mp})$$

- To choose appropriate Set I_c regarding current status of service composition, the mediator executes Task M_{st}.
- Task M_{st} changes links by considering Set I_{mp} of measurement values originated from Set I_c and Set R_{mp} of measurement values on resource availability.

Service Monitoring

$$q = P_{mon}(G, I_{mp}, R_{mp})$$

- Task P_{mon} periodically gathers the monitoring results I_{mp} and R_{mp}, and calculate performance index q.
  - Set I_{mp}: measurement values originated from Set I_c
  - Set R_{mp}: measurement values on resource availability
- Performance index q exerts a influence on decision whether to keep current service composition or to take appropriate actions to remedy problematic symptoms.
- This decision is depending on the performance index q reflecting resource efficiency of target service composition.

Future work

- To verify this conceptual approach, we needs validating its feasibility (i.e., resource-efficient service composition) over Future Internet testbeds.

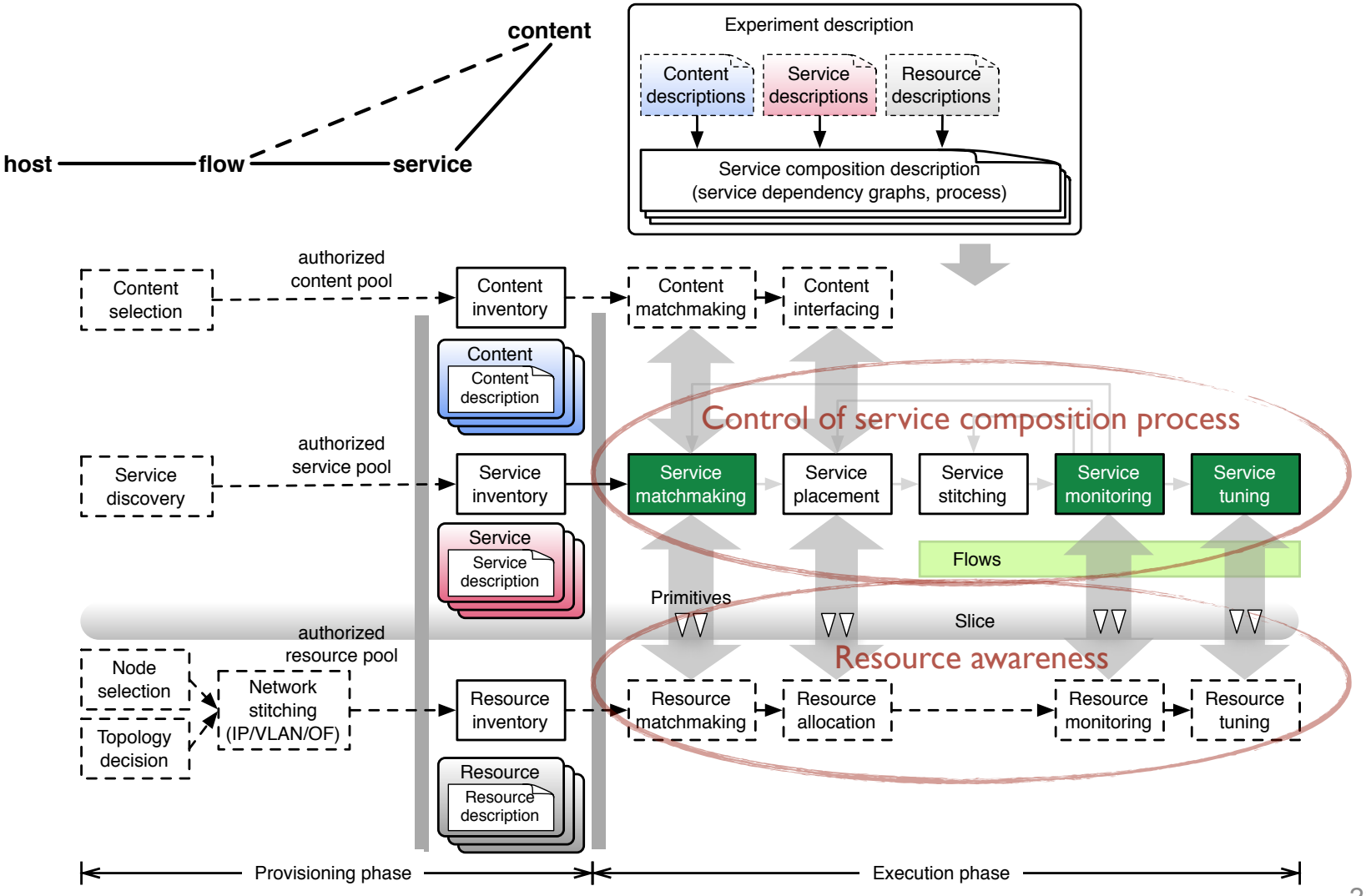
- In doing so, we will continue appropriate refinements of the proposed process, tailoring to the target experiment scenario.

BACKUP SLIDES

A brief review on service composition

- Web Service composition
  - A service composition is comprised of services that have been assembled to provide the functionality required to automate a specific task or process
- Multimedia service composition (via Service Overlay Network)
  - Controlling a composed flow for continuous, timely, quality-aware and synchronized media delivery
  - Coordinating different adaptive techniques in end-to-end composed services over heterogeneous devices and networks

Resource-aware media-centric service composition process



Multiple options for media-centric service composition process