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Introduction to Robotics
Lecture 12

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T|A
M|S

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Technical Aspects of Multimodal Systems

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Introduction

Spatial Description and Transformations

Forward Kinematics

Robot Description

Inverse Kinematics for Manipulators

Instantaneous Kinematics

Trajectory Generation 1

Trajectory Generation 2

Dynamics

Robot Control

Path Planning

Task/Manipulation Planning

Telerobotics

Architectures of Sensor-based Intelligent Systems
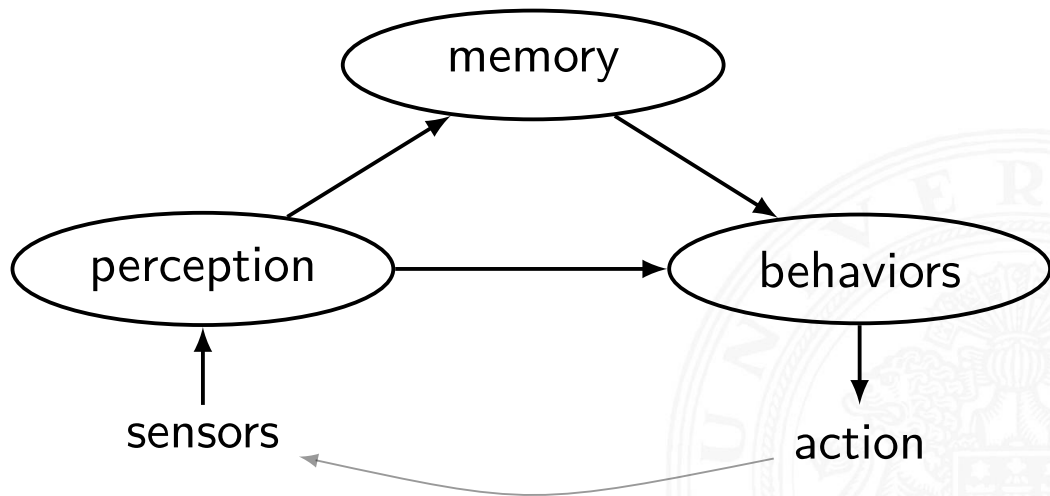
Architectures of Sensor-based Intelligent Systems

Overview

- ▶ Basic behavior
- ▶ Behavior fusion
- ▶ Subsumption
- ▶ Hierarchical architectures
- ▶ Interactive architectures

CMAC: `Cerebellar Model Articulation Controller`

S sensory input vectors (firing cell patterns)

A association vector (cell pattern combination)

P response output vector ($\mathbf{A} \cdot W$)

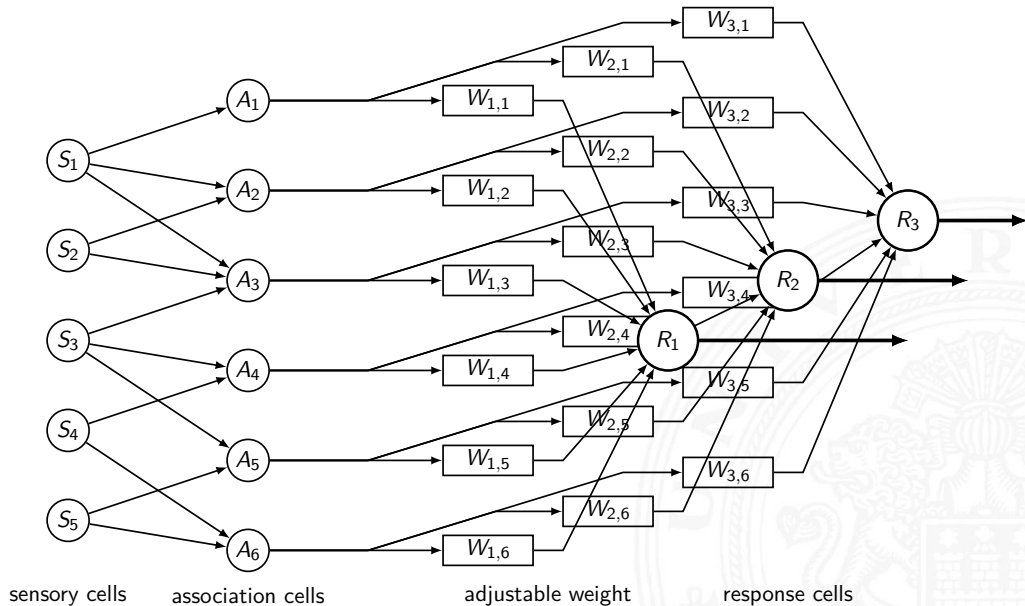*W* weight matrix

The CMAC model can be viewed as two mappings:

$$f : \mathbf{S} \longrightarrow \mathbf{A}$$
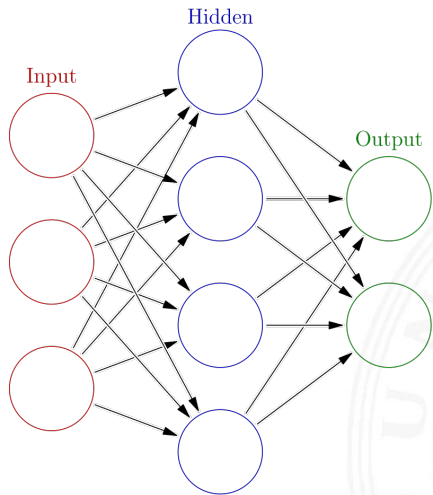$$g : \mathbf{A} \xrightarrow{W} \mathbf{P}$$

CMAC-Model (cont.)

sensory cells   association cells   adjustable weight   response cells
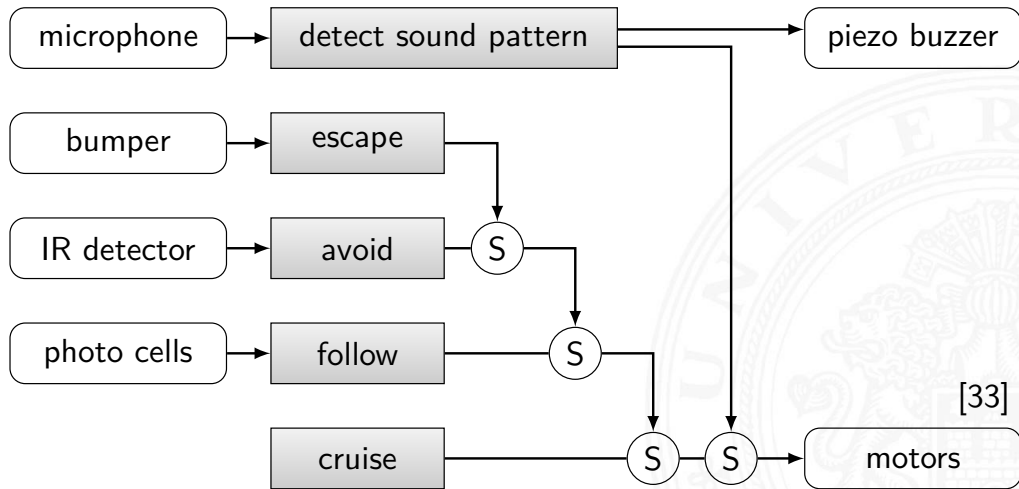
Artificial Neural Network

Artificial neural networks (ANN) or connectionist systems are computing systems vaguely inspired by the biological neural networks that constitute animal brains.
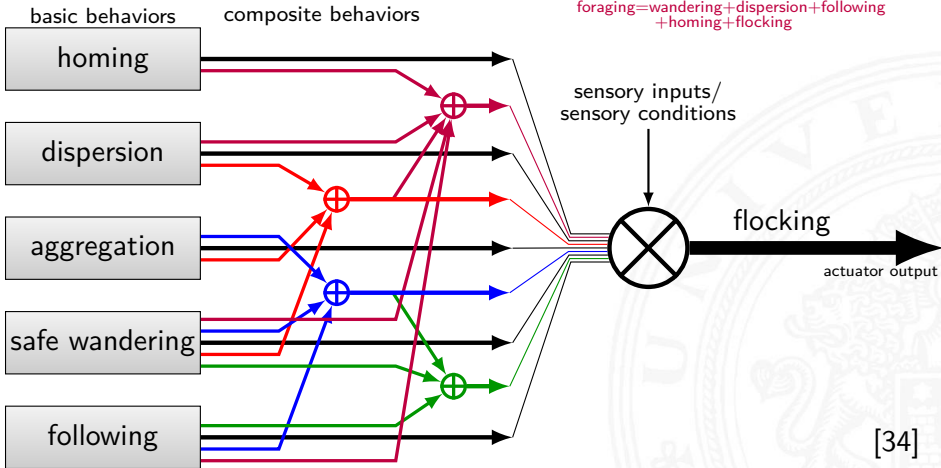
The Subsumption Architecture

- ▶ hierarchical structure of behavior
- ▶ higher level behaviors subsumpe lower level behaviors

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Foraging and Flocking

- ▶ multi-robot architecture
- ▶ basic behaviors are sequentially executed

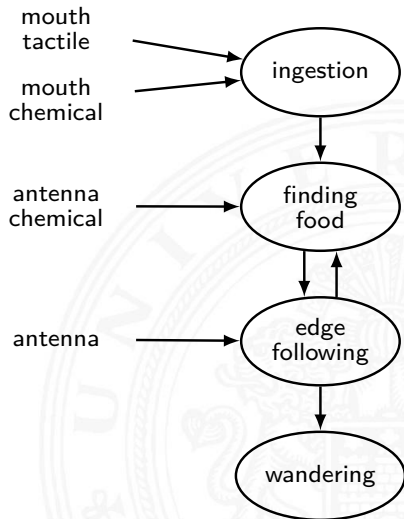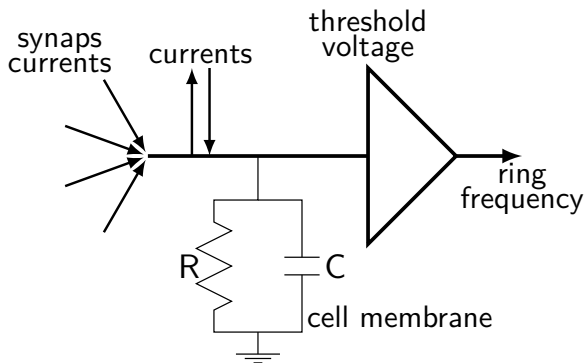flocking=wandering+aggregation+dispersion
surrounding=wandering+following+aggregation
herding=wandering+surrounding+flocking
foraging=wandering+dispersion+following
+homing+flocking

[34]

| SENSORS | BEHAVIORS |

mouth
tactile

mouth
chemical

ingestion

synaps
currents

currents

threshold
voltage

antenna
chemical

finding
food

ring
frequency

R

C

cell membrane

antenna

edge
following

wandering

Control Architecture of a Fish

Control and information flow in artificial fish

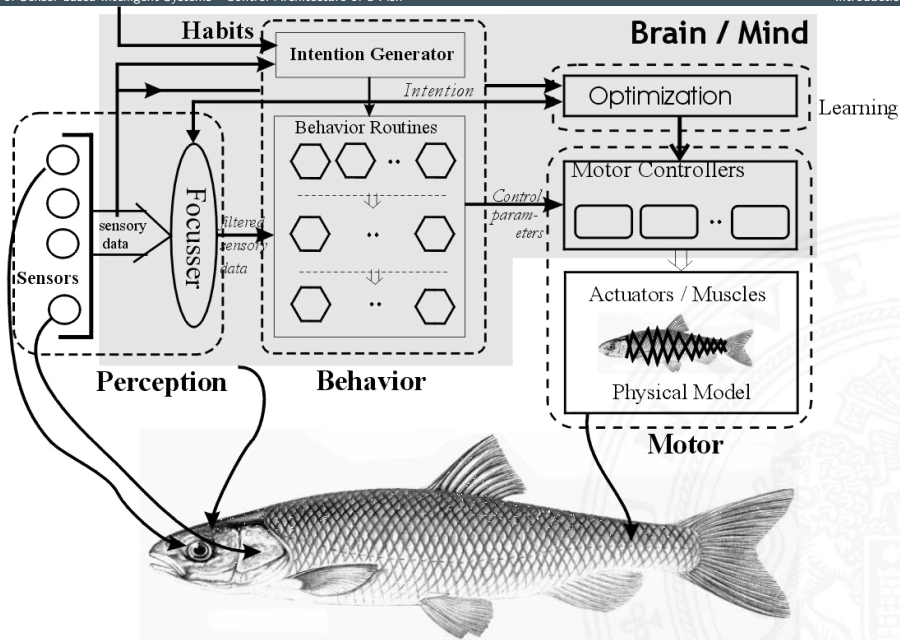Perception sensors, focuser, filter

Behaviors behavior routines

Brain/mind habits, intention generator

Learning optimization

Motor motor controllers, actuators/muscles

Control Architecture of a Fish (cont.)
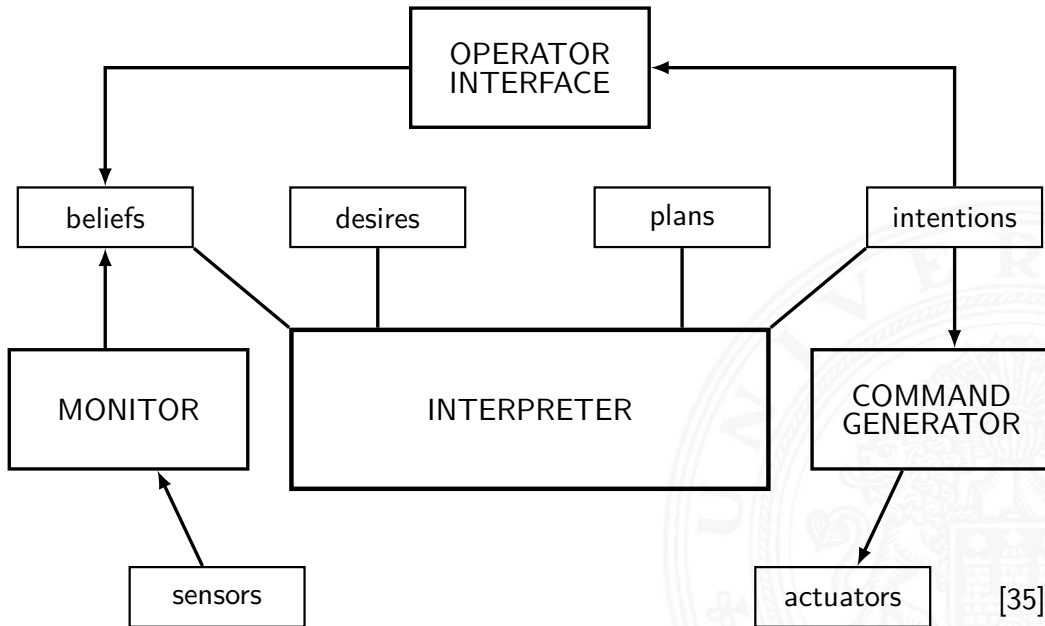
Real-Time Control System (RCS)

▶ RCS reference model is an architecture for intelligent systems.

▶ Processing modes are organized such that the BG (Behavior Generation) modules form a command tree.

▶ Information in the knowledge database is shared between WM (World Model) modules in nodes within the same subtree.

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Examples of functional characteristics of the BG and WM modules:

Level IV — Recognition of relations of objects

Level III — Descriptions of relations of objects or unrecognized aggregates

Level II — Recognition of aggregates of features (objects)

Level I — Descriptions of aggregates of points and their features (object elements)

Level 0 — Properties of points in space

raw data

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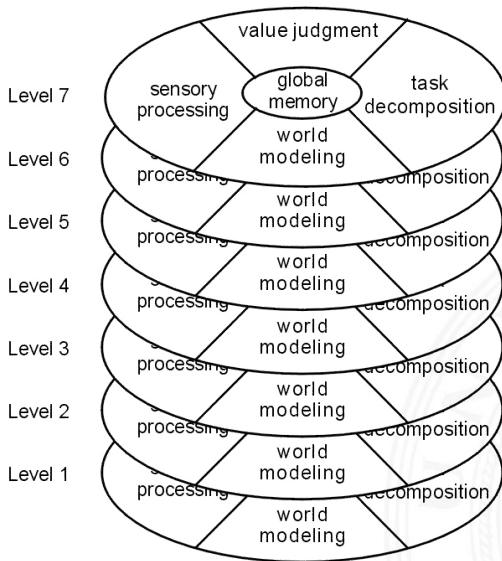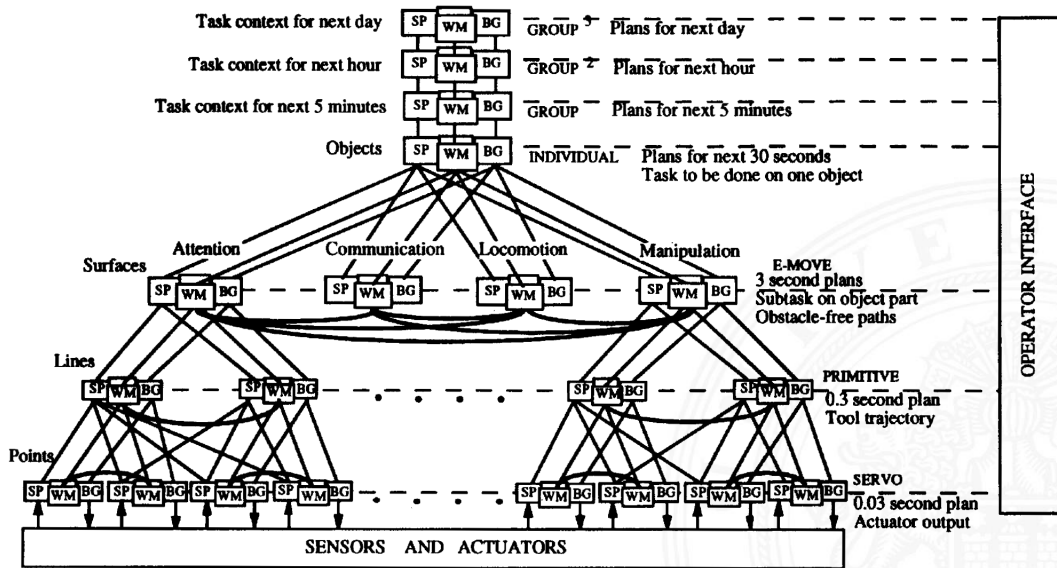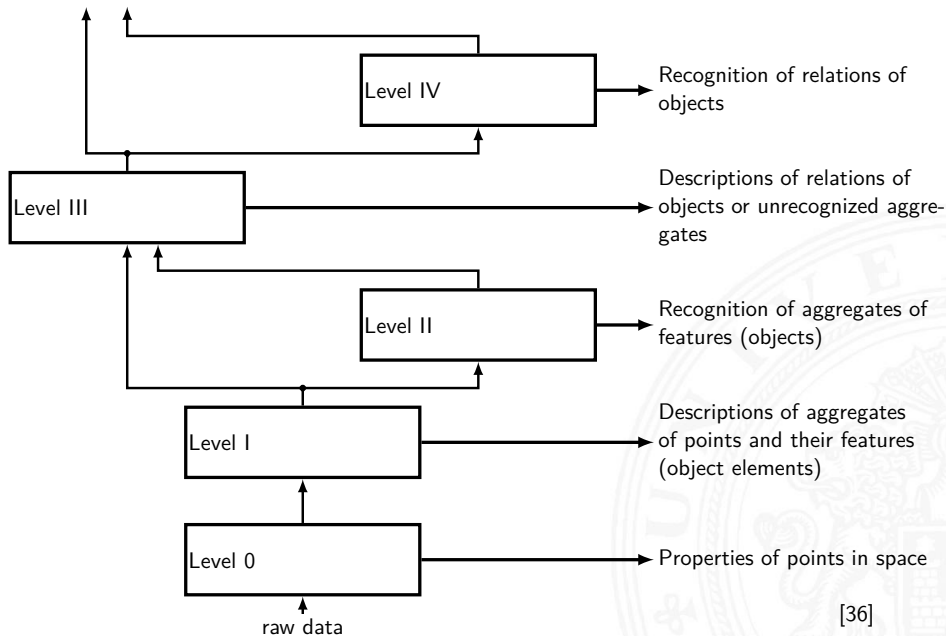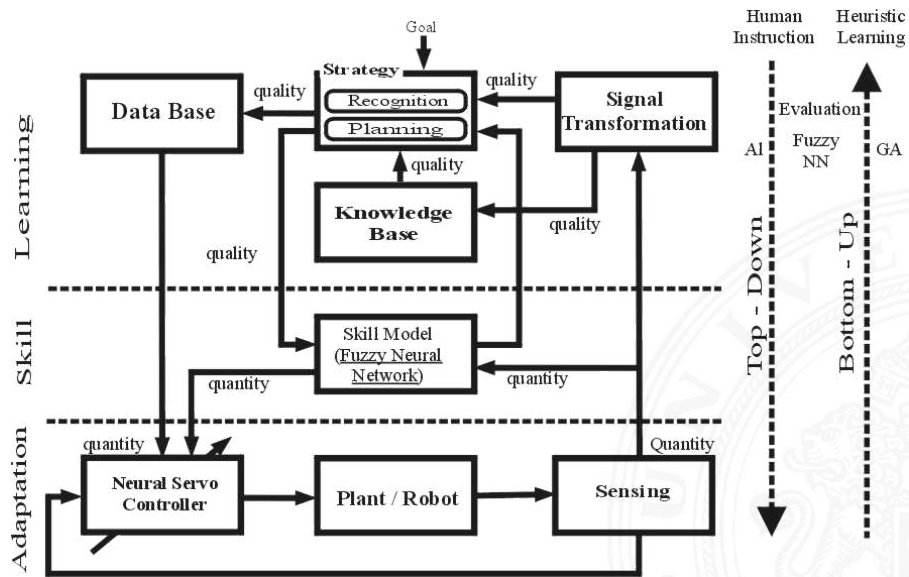
[37]

RACE
Robustness by Autonomous Competence Enhancement

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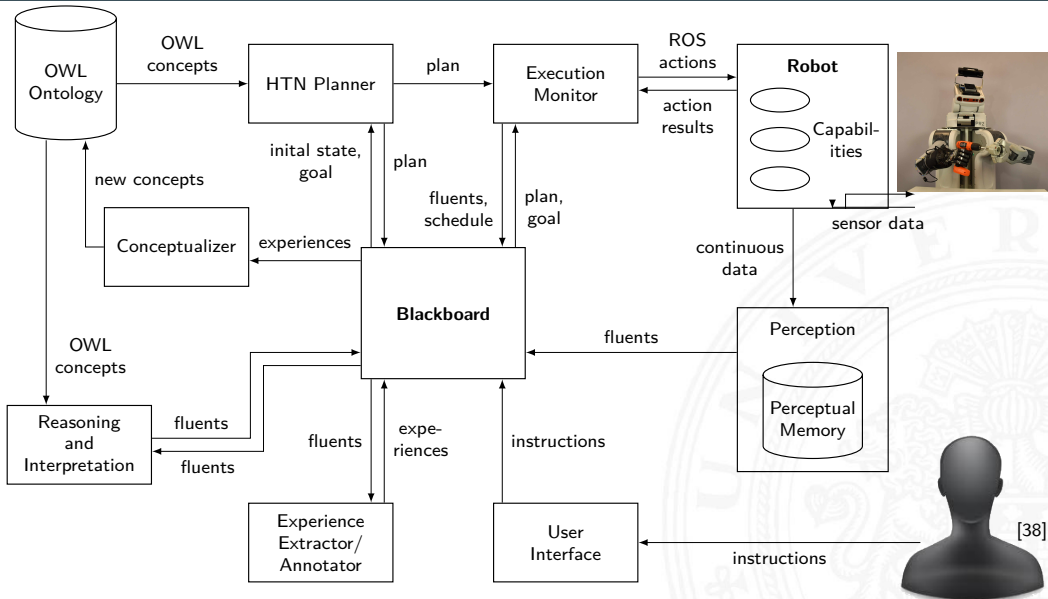
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