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Efficient management of hydrographical networks in a global change context

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Hydrographical networks are large-scale and complex systems used to answer the Human needs. Their management strategy is mainly based on their objectives and their characteristics, while satisfying the sharing of the water resource between usages. As an example, inland waterways are dedicated to navigation, but are also used to route water and supply industries, answer to drinking water and agricultural demands. Irrigation networks are dedicated to agricultural demands but can also supply industries and answer to drinking water demand. Therefore, the management of hydrographical networks must meet several objectives, while knowing that the water resource is a strongly constrained resource. Mainly constraints related to human needs in terms of agriculture, drinking water, navigation, industries, and finally energy have also to be considered. This last constraint is growing up very quickly with the equipment of hydrographical networks with ICTs (controlled actuators and remote sensors), with pumps and more recently with hydroelectric turbines for low loaded location, as an example locks in inland waterways. This new equipment gives response elements for most of the problems. However, the increase of human needs and equipment induces an expertise that moves from humans to machines and a constraint on energy that is taking more and more importance. In this context, the management of water resource has to limit energy consumption and to increase energy production. Finally, hydrographical networks as environmental systems would be strongly impacted by global change. Uncertainties on the possible impacts of global change are still big even if these impacts can be estimated more and more precisely. Hence, even if the management of hydrographical networks is studied for several years with the design of modelling tools, control architectures, remote control systems etc., it is still an open challenge.
By focusing on inland waterways, we have designed a management architecture that improves efficiently the management of hydrographical systems. The strategy considers two scales of space and time to optimize the water resource allocation amongst the inland networks and to guaranty the navigation conditions by proposing advanced control and fault detection tools. To reach the overall objectives, the management architecture implements several tools and methods for optimal water resource planning. Algorithms based on Constraint Satisfaction Problem (CSP), methods based on quadratic optimization and on Markov Decision Process (MDP) have been developed. However, the proposed management architecture still needs some improvements to deal with uncertainties, energy consumption optimization energy production, etc. Moreover, we want to develop and coalesce into the proposed architecture an earliest arrival flows model in order to answer to the requirement of water evacuation to the sea in flood period. Some examples and algorithms have been proposed in the literature but most of them did not take into account multiple sinks or time delays.