Integrated Modeling for Road Conditions Prediction: System Architecture Description

October 24, 2022

Final

U.S. Department of Transportation
Federal Highway Administration

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS

ADCIRC	Advanced Circulation model for oceanic, coastal, and estuarine waters
AHPS	Advanced Hydrologic Prediction Service
ATMS	Advanced Transportation Management System
C2C	Center to Center
CAP	Common Alerting Protocol
ConOps	Concept of Operations
CV	Connected Vehicle
DEM	Digital Elevation Map
DMS	Dynamic Message Signs
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
GFS	Global Forecast System
IMRCP	Integrated Model for Road Condition Prediction
LADOTD	Louisiana Department of Transportation and Development
MDSS	Maintenance Decision Support System
METRo	Model of the Environment and Temperature of Roads
MLP	Machine Learning-based Prediction
MRMS	Multi Radar Multi Sensor
NDFD	National Digital Forecast Database
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
RAP	Rapid Refresh weather model
RTMA	Real-Time Mesoscale Analysis
SAD	System Architecture Description
TMC	Transportation Management Center
URL	Uniform Resource Locator
USDOT	United States Department of Transportation
WxDE	Weather Data Environment

CHAPTER 1. INTRODUCTION

BACKGROUND

FHWA has embarked on efforts to describe and create a tool that results from an ensemble of forecast and probabilistic models and incorporates real-time and/or archived data, fusing them to predict current and future overall road/travel conditions for travelers, transportation operators, and maintenance providers.

The foundational elements needed to characterize Integrated Modeling for Road Condition Prediction (IMRCP) were developed in the Phase 1 development of a Concept of Operations and Requirements. The IMRCP Phase 2 work specified, implemented, tested, and evaluated the IMRCP concept in a demonstration deployment with local agencies in the Kansas City metropolitan area. Phase 3 expanded the IMRCP deployment across the entire Kansas City metro area, implemented a machine-learning based traffic model, operated the system for two winter seasons, evaluated the operational results, and updated the system documentation

PURPOSE

The objectives of IMRCP Phase 4 are to improve and deploy the system in two new locations (Ohio and Louisiana), expanding system capabilities and applicability to extreme events. This will address some gaps and recommendations from Phase 3; deploy to a metropolitan area for planning, monitoring, and post-event assessment of traffic management during adverse weather conditions; deploy to a metro/region/state transportation management center to assess improvements to public safety, evacuation and emergency response to severe/extreme weather conditions; and update the system documentation to support future deployments. This System Architecture Description updates the Phase 3 architecture to reflect system changes needed to support the Phase 4 scope and objectives.

SCOPE

IMRCP provides a framework for the integration of road condition monitoring and forecast data to support tactical and strategic decisions by travelers, transportation operators, and maintenance providers. The system will collect and integrate environmental observations and transportation operations data; collect forecast environmental data and operations data when available; initiate road weather and traffic forecasts based on the collected data; generate travel and operational advisories and warnings from the collected real-time and forecast data; and provide the road condition data, forecasts, advisories and warnings to other applications and systems. Road condition and operations data and forecasts to be integrated into the predictions may include atmospheric weather; road (surface) weather; small stream, river, and coastal water levels; road network capacity; road network demand; traffic conditions and forecasts; traffic control states; work zones; maintenance activities and plans; and data related to emergency preparedness and emergency operations.

DOCUMENT OVERVIEW

The structure of this document is generally consistent with the outline of a System or Software Architecture Description defined in ISO/IEC/IEEE Standard 42010-2011. Some sections have been enhanced to accommodate more detailed content than described in the standard. Titles of some sections have been edited to specifically capture that enhancement.

The first two sections provide a general description of the system perspective and stakeholder concerns. They generally comprise a summary of material described in more detail in the Concept of Operations.

The two subsequent sections document the system architecture. The relevant architectural viewpoints are identified, and views and models are described for each viewpoint. Rationales for and correspondence between elements of the views are included in the view and model descriptions. Three viewpoints are described: composition, process, and deployment.

CHAPTER 2. SYSTEM PERSPECTIVE

Note: This section was previously published in the Integrated Modeling for Road Condition Prediction System Requirements Specification.

Describing and predicting roadway conditions and events that may impact travel across road networks requires the understanding and use of tools for interacting with the system and its operations across all of the road network's stakeholder groups. For example, travelers have an immediate need for information about conditions along their planned route and contribute to the aggregate travel conditions along their route by their choices and behaviors. Winter maintenance crews plan ahead for reducing the impact of storms on roadway conditions based on weather forecasts and perhaps on a sophisticated maintenance decision support system (MDSS), but also adapt to conditions on the roadway as they execute those plans. Operators in a Transportation Management Center (TMC) monitor roadway conditions across a network with cameras and sensors accessed through an advanced transportation management system (ATMS), and respond to conditions and events by generating alerts to be published on dynamic message signs (DMS) on the roadside and pushed out to web pages and mobile apps through traveler information systems. In all of these examples, stakeholders are making and executing plans, monitoring and adjusting to current conditions, and potentially changing their plans based on their analyses of potential future conditions.

A complete context for predicting road conditions would have to consider a broad range of stakeholders, their activities and interactions with the roadway, their decision processes, and the underlying models of the roadway and environmental conditions. Descriptions of the current state of stakeholders and their activities in the IMRCP ConOps therefore focused on identifying the processes and decisions that are affected by currently available roadway condition information and predictions. An analysis of current and imminent road and weather condition models was documented in the Integrated Model for Road Condition Prediction Model Analysis. The aggregate of these analyses of modeling capabilities and stakeholder interests formed the basis for the functional and system package architectural views of a potential IMRCP system in the ConOps. This SAD builds and expands upon the conceptual views described in that ConOps.

CHAPTER 3. STAKEHOLDERS AND CONCERNS

GENERAL CONSIDERATIONS

Transportation system stakeholders need road condition information to help them make appropriate travel and traffic management decisions. For example, information about conditions on the road immediately ahead of a traveler is useful. Information regarding the road they might take at the next decision point is only slightly less useful, and information on the road behind them is not useful at all. One concern is that too much information outside a user's context may distract the user from more immediate and relevant information. Further, potential road condition predictions are useful only if they are relevant to the traveler's temporal and spatial context. This has significant ramifications for predictive capabilities. Traffic data provided to managers and travelers has until this point generally been limited to observed conditions, but predictions could have more dramatic decision implications. Information must be timely enough to facilitate effective decisions based on anticipated conditions. For instance, informing a traveler that severe congestion is likely for the next 30 minutes in the middle of a 1- hour commute is much less effective than having issued the advisory 90 minutes earlier.

Users need road condition predictions expressed in clear terms consistent with other similar contexts that help their decision processes. Traffic information and signage already provide some information of this type; travelers understand what an "icy road ahead" or a "deer crossing" sign means. Such signs are used to express likelihood, and provide an advisory appropriate to the traveler's immediate decision context. Predictive capabilities expand this concept to provide quantified likelihoods. The public is used to seeing probabilities provided in weather forecasts; traffic forecasts could be expressed in similar terms. In some contexts it may be appropriate to describe the level of confidence for the prediction.

Users need access to predictions through existing interfaces that provide similar traffic and weather information. Providing additional information of familiar types through existing channels is more effective in the near-term than establishing new channels specific to the additional information. Consumers of traffic and weather condition information already have access to traditional media, websites, and social media. It would likely be more efficient to supplement those channels with predictive capabilities rather than to develop new apps for publishing road condition predictions. Nonetheless, a user interface specific to the IMRCP will be useful for some stakeholders and will be needed during system development, testing, and foundational deployment.

User needs for decision support are not, however, directly changed by the availability of road condition predictions. A traveler, for example, might look for routing guidance in travel planning. Road condition predictions are an input to the guidance, not the reason for initially seeking it. As such, the "users" of the predictions are, in this case, the routing system rather than the end user. Road weather MDSS demonstrate this in practice; the precipitation and icing forecasts are embedded in the analysis of decision support planning.

METEOROLOGISTS

Forecasting meteorologists provide atmospheric weather and, in some cases, road condition forecasts for use by transportation system stakeholders. The base forecasts are typically generated by sophisticated simulations of atmospheric physics as summarized in the IMRCP *Model Analysis* report. Multiple simulations using a variety of physics models may be aggregated into an ensemble model in an effort to improve confidence in the results. Meteorologists working for a transportation agency interpret the forecasts for other agency users in operations planning and support. In regions subject to significant and regular winter storms, meteorologists may use the atmospheric forecast as input to road weather forecasts to predict precipitation types and accumulations on the roadway. Meteorologists are stakeholders in the IMRCP, but are not direct users of its computational products.

TRAFFIC SIMULATION

Traffic researchers and modelers develop and use simulations of roadway networks and travel demand and behavior to predict traffic conditions on roadways. A large number and variety of traffic models are available and summarized in the IMRCP Model Analysis report. Traffic modelers may work with or in any functional area within a transportation agency. Models are needed in planning to assess the need and potential for traffic improvements from infrastructure and intelligent transportation systems (ITS) deployments. Traffic simulations in construction and work zone management can be used to support safety and mobility assessments. Simulations and forecasts can support signal timing planning and other traffic control analyses in operations. Traffic researchers and modelers are stakeholders and developers of IMRCP capabilities, but are not direct operational end users of its products.

TRANSPORTATION OPERATIONS

Transportation operations personnel monitor traffic and roadway conditions, manage traffic controls, respond to incidents, and provide traveler information throughout a road network, typically through systems provided in a TMC. Operators work with roadway maintenance personnel to identify maintenance needs, manage traffic, and provide traveler information during maintenance events. Likewise, operators work with public safety and emergency response units during incidents. Operators monitor weather conditions and forecasts for their potential impacts on safety and mobility. Operations personnel may use traffic simulations to support assessment of operations strategies in response to weather, incidents, and special events.

The IMRCP will enable operations personnel to make more effective traffic management decisions by providing access to forecasts of potential operational conditions and events as they might transpire in response to those decisions. This represents a significant advancement from the practices prevailing at many TMCs, where ad-hoc implementation of weather management strategies based on current conditions is more typical. The IMRCP plays a critical role in enabling the adoption and deployment of modern system management approaches.

TMC operators need and currently have access to measures such as traffic speeds, volumes and travel times. Their most critical information needs are those that enable them to “get ahead of the game,” to make decisions about activating traffic controls before problems develop and prepositioning assets, safety services, and staffing. Operators want to enable condition-responsive operations strategies earlier, based on high-confidence anticipatory conditions.

Agency operations are typically responsive to observed traffic conditions. The most established anticipatory strategy is using a time-of-day strategy for traffic signal timings. The natural extension of this model is to use a dynamic proactive model to address issues before a problem emerges. This approach is based on traffic measures and observed data, but predicts future conditions as well. In current practice, the specific means of generating and presenting the prediction is not critical; the emphasis is on focusing operator attention on potential issues rather than predicting a specific network state. At the Kansas City Scout TMC, for example, National Weather Service (NWS) alert zone polygons were overlaid onto network traffic maps. Operators were given beginning-of-shift predictions as a starting point from which they could then monitor conditions and make adjustments. Providing more specific predictions would enable a more accurate and measurable implementation of operations strategies.

MAINTENANCE

Maintenance personnel are responsible for preserving and extending the use of transportation infrastructure. They carry out day-to-day protective and repair measures to limit degradation due to natural (e.g., weather) or imposed processes (e.g., traffic). During winter, maintenance personnel are responsible for maintaining and restoring roadway surface conditions after weather events. Forecasts of atmospheric and roadway weather conditions are essential inputs to these maintenance operations in every stage of an event. Operations may include pre-treatment to reduce freezing of precipitation on roadways, plowing to remove accumulated snow and ice, and distribution of sand and similar traction-enhancing material. Maintenance planning and operations may be supported by an MDSS that uses forecasts and maintenance strategies to plan material application and plowing operations. In other seasons, maintenance personnel are also responsible for routine rehabilitation and preventative maintenance of the roadway. These functions include activities such as pavement management and maintenance, shoulder maintenance, bridge inspection and maintenance, and vegetation management. Maintenance personnel may also participate in more general work zone activities distinguished from “maintenance” by longer-term fixed-locations (for reconstruction type activities) and sustained lane closures.

Winter maintenance units in some agencies have had access to predictive capabilities with MDSS for some time. The integration of weather and traffic predictions, however, will offer new layers of traffic information to facilitate better prioritization of routes for pre-treatment and plowing. Non-winter maintenance activities—striping, mowing, sign maintenance—will have a tool with which to make more informed decisions on scheduling and prioritization of work, enabling more efficient use of resources and reduced risks to maintenance workers, travelers, and property.

Winter maintenance strategies and practices vary widely among agencies, but maintenance personnel need and benefit from access to road condition data, including pavement temperatures, air temperatures, precipitation rates and accumulations, and wind speeds and direction. Atmospheric weather forecasts are essential to operations planning, and pavement condition forecasts can be used to more precisely plan pre-treatment and snowplow routing. Some agencies have invested in MDSS to aggregate and automate analysis of these data in support of winter operations. Integration of road weather condition predictions with traffic condition forecasts would provide a basis for even more accurate and effective operations by fine-tuning road condition predictions and plow routing to more quickly and effectively restore traffic capacities.

Non-winter maintenance operations have not received the level of needs analysis and support provided for winter maintenance, primarily because the operational impacts on the roadway are not as dramatic. As shown in the *Clarus*-enabled Services project,[1] weather forecasts are helpful in planning and scheduling weather-sensitive maintenance tasks such as signage replacement (high winds), striping (pavement moisture and temperature), and spraying herbicides and growth retardants (wind speed and direction). Integrating traffic and weather forecasts could further mitigate any operational risks to workers and the traveling public.

WORK ZONES

Work zones are operationally complex for agencies, presenting safety concerns for workers and mobility and safety challenges for travelers. Agency and contractor preparations and operations for work zones may involve personnel from planning, occupational safety, roadway design, materials, traffic operations, traffic safety, permitting, maintenance, and public information. Traffic simulations may be used in planning construction and maintenance to assess the impact of the roadway configuration on traffic flows but are not generally updated during work zone operations. Weather conditions are a key factor in work zone operations and safety but are not likely to be factored into operational planning simulations.

The IMRCP provides an ideal platform for achieving closer coordination between agency and contractor personnel in work zones. Data integration and prediction capabilities in the system can greatly facilitate management of disruptions, especially weather-induced disruptions, as agencies adjust plans for anticipated or prevailing bad weather and jointly implement traffic control measures alongside construction operations.

EMERGENCY OPERATIONS

Emergency transportation operations deal with non-recurring events affecting the transportation network. These operations include traffic incident management, traffic planning for planned special events, and emergency transportation operations for disasters. Personnel involved in preparing for and responding to these events need information about roadway conditions insofar as they may impede or delay the management of the events. In the case of disasters, roadway conditions may be a direct factor in the event. Flooding, for example, may make roadways impassable or damage the infrastructure. This has the effect of both limiting the emergency response to the flooding and requiring a response to the degradation of the roadway network. Hurricane evacuation planning requires a detailed knowledge of weather and road conditions to ensure that the evacuation plan is appropriate to the event as it unfolds; faulty or incomplete information applied to the response plan could exacerbate traffic conditions.

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[1] Gopalakrishna, D. and C. Cluett (2011). *Clarus Multi-State Regional Demonstrations, Evaluation of Use Case #3: Non-Winter Maintenance Decision Support System*. USDOT/FHWA, Report No. FHWA-JPO-11-118.

Emergency responders and evacuation planners have to be flexible in their plans and include recourse actions in the event of specific outcomes, especially given the uncertainty in weather conditions and in how they may affect communities. The IMRCP offers a new critical capability for assessing, adjusting and reconfiguring precautionary measures and responses to major disruptions and potentially disastrous events.

TRAVELERS

Traveler information needs have been well studied and documented. At the risk of oversimplifying, travelers benefit from advance knowledge of traffic speeds, travel times, incident locations, work zone locations, and road closures. En-route travelers benefit from notifications of changes in any of those conditions. The typical traveler is not conscious of weather conditions until they affect visibility or control of the vehicle. Integrated road condition predictions could potentially provide travelers with more specific and trustworthy information on road conditions before they encounter them, but the information would need to be accessible and understandable. To that end, road condition predictions would need to be made available through familiar interfaces (for example, roadside DMS, 511, mobile traffic apps) and in familiar terms.

Commuters constitute the largest component of daily traffic load in most cities. Their aggregate travel decisions are the source of recurring congestion and are subject to change from any weather variation, incident, or special event. They are a potential source of traffic data through their part in the traffic flow measured by traditional vehicle detection, social media participation, and aggregate traffic data systems. They are also users of traveler information through traditional media, ITS (dynamic message signs (DMS) and highway advisory radio (HAR)), 511 phone and web systems, mobile traffic applications, and social media. The impact of commuter travel decisions on traffic conditions provides a direct, although soft, feedback mechanism for influencing traffic conditions through traveler information, without direct deployment of traffic controls.

Commuters generally know what travel times to expect on their regular routes and depend on having reliable travel times to ensure that they get to their destinations on schedule. Unusual events, such as incidents and inclement weather conditions, challenge that reliability and create frustration. An integrated predictive capability will provide more information on which to base travel decisions, giving commuters a basis for better aligning their expectations with likely conditions and providing information about alternative routes.

Recreational travelers are the opposite of commuters in terms of their behavior within the transportation system. Their travel decisions are much more variable, even in the aggregate sense. Their travel demand is subject to greater seasonal, day-of-week, and even hour-of-day variability. Their relative lack of familiarity with local roads and conditions makes them more vulnerable to unusual weather and traffic conditions and necessitates more specific traveler information and recommendations than for users more familiar with the roadways.

Recreational travelers typically have more travel options but less knowledge about local travel conditions. They have more flexibility to adapt their plans to changing conditions, if given the information needed to make those decisions. Although weather forecasts are widely available and have become reasonably reliable, the integration of road condition and weather predictions through the IMRCP would provide a new level of awareness of travel conditions. Travelers taking advantage of the integrated forecast advisories would be less likely to run into potentially dangerous conditions and be able to make schedule and routing decisions around local and regional travel challenges.

While travelers are often categorized only by vehicle types and sizes, with freight representing trucks whose operators may respond to weather and road conditions the same way any driver would, this view is incomplete. Unlike individual travelers in light vehicles, freight vehicles operate according to elaborate logistics decisions made by a chain of actors. These include shippers as well as carriers, and an entire logistics ecosystem of distribution centers, warehouses, terminals, intermodal yards and receiving facilities. Their travel decisions have significantly higher complexity and consequences that those made by commuters or recreational travelers. As such, freight operations and drivers have greater needs and incentives for accurate and timely travel information.

Freight operators and drivers depend on accurate and timely traffic and weather condition information to meet their operational objectives. Hence, while advising a truck to divert or delay a trip may be essential under extreme weather or road conditions, predictive information can considerably reduce the economic consequences of such disruptions. Shippers often have the option to fulfill customer demands from different distribution centers with national and regional footprints. If the IMRCP predicts bad weather that will severely impact certain routes, fulfillment could proceed from a different distribution center that may be more secure and less exposed. Decisions thus range from selecting particular routes for trucks, to assigning different trucks to pick/up deliver certain loads, to the choice of different distribution centers, to the selection of alternate suppliers, to changes in scheduling certain activities, and so on. This affects both long-haul transportation and last-mile delivery and drayage operations.

CHAPTER 4. SYSTEM ARCHITECTURE DESCRIPTION

The system architecture is described in a set of three architectural views: composition, process, and deployment. The composition view describes the components with the OMG Unified Modeling Language™ (UML)[2] package diagram. The process view uses UML activity diagrams to describe procedural methods implemented in the packages described in the composition view. The deployment view allocates packages to particular computing devices on UML deployment diagrams. The requirements from which the architecture derives are documented in the *Integrated Modeling for Road Condition Prediction System Requirements Specification*.[3]

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[2] Object Management Group, "OMG Unified Modeling Language™ (OMG UML) Version 2.5," OMG Document Number: formal/2015-03-01, Normative Reference: http://www.omg.org/spec/UML/2.5. Accessed June 15, 2018.

[3] Leidos, *Integrated Modeling for Road Condition Prediction System Requirements Specification* (unpublished working paper developed under Contract DTFH61-12-D-00050, Integrated Modeling for Road Condition Prediction), January 26, 2016.

CHAPTER 5. COMPOSITION VIEW

The composition view describes the system in terms of sets of software components and their relationships. A Unified Modeling Language package diagram is used to present an integrated high-level view as shown in Figure 1.

The composition view of the design generally flows from the functional outline of the requirements. Packages and their sub-components are described below.

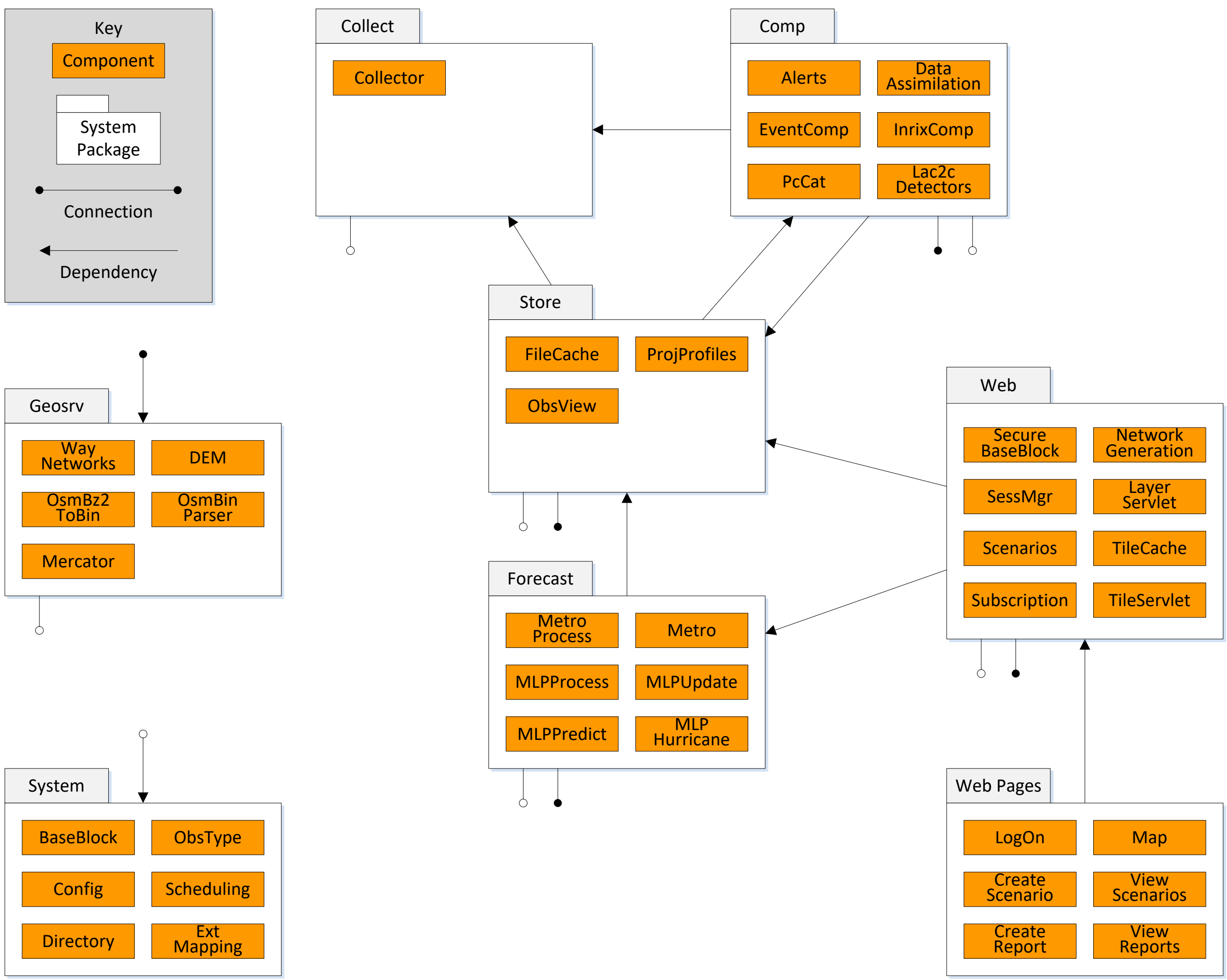


Figure 1. Diagram. IMRCP Composition.

(Source: FHWA)

FORECAST

The Forecast package contains modules that produce near-term and long-term forecasts in real time. There are two prominent forecasting models included in IMRCP: METRo for pavement conditions and MLP for traffic condition

The METRo model was developed by the Canadian Meteorological Center of Environment Canada as a standard pavement thermal modeling tool within its road weather forecasting suite. It is widely used and adapted in many winter maintenance decision support systems, including NCAR's Pikalert suite.

The Machine Learning-based Prediction (MLP) model predicts traffic network conditions given a set of system variables that include weather, work zones, incidents, and special events. MLP is a comprehensive, data-driven prediction module that uses a Markov process to explicitly characterize the probabilistic transition between traffic states under different external conditions (e.g., weather, incidents).

A Markov stochastic process is used to model the randomly evolving system with the assumption that future states depend only on the current state. A Markov transition matrix consists of a set of probabilities that are used to represent the transition probabilities between different traffic states. It is built based on archived data and can be applied online using real-time feeds to generate precise prediction models and results. With a calibrated Markov model, the probability of transition between traffic states under different external conditions can be computed. The algorithm considers that the environment variables (e.g., weather) and the external event variables (e.g., incidents) affect the transition probability matrices between different traffic states. A decision tree model constructed based on the historical data is used to determine whether the external events will affect the traffic states and whether the Markov model will be applied. The time series model takes online data as input to reflect the most current traffic conditions observed in the field. This makes the prediction model robust, particularly during special conditions that have traffic patterns that are different from regular scenarios.

METRo

The METRo module is a class within the MDSS package that computes pavement and subsurface thermal characteristics based on road weather conditions and pavement geometries and materials.

As described in the IMRCP Model Analysis, METRo is a standard pavement thermal modeling tool developed by the Canadian Meteorological Center of Environment Canada as part of its road weather forecasting suite. It is widely used and adapted in many winter maintenance decision support systems, including NCAR's Pikalert suite. In the IMRCP architecture, METRo is implemented as part of its MDSS package to support RCTM treatment recommendation analyses.

The IMRCP implementation of METRo depends on the data Store for road weather forecasts and segment definitions.

METRo Scenario Assessment

The Scenarios module uses the METRo model to make long term pavement state and temperature for the roadway segments included in created scenarios. This MetroProcess component depends on the data Store, roadway segment definitions, and the Scenarios module.

Machine Learning-based Prediction [MLP]

The Machine Learning-based Prediction (MLP) package predicts traffic speed given a set of system variables, including weather, roadwork, incidents, and traffic control strategies. MLP is a comprehensive data-driven prediction module that uses a Markov process to characterize the probabilistic transition between traffic states under different traffic scenarios. The MLP package contains the MLP Scenario Identifier, Traffic Predictor, and Update Manager classes.

Input to the MLP package includes data from the data Store such as traffic, weather, work zones, incidents, and traffic control states. The outputs of the MLP package are the predicted traffic speed for the selected time horizon (such as 15 min, 30 min, 1 hour).

MLP Scenario Identifier [Scenario Ident]

The Scenario Identifier is a module within the MLP package that identifies what specific scenario the current traffic condition belongs to and then selects a corresponding model for traffic-state prediction. This module will use an approach based on decision tree classification and pattern recognition for scenario identification.

The MLP Scenario Identifier module within the MLP package contains two parts: a Scenario Identifier and a Markov Model Generator, the latter of which is computed from the archived data. The Scenario Identifier is a submodule that identifies the specific scenario the current traffic condition belongs to and then selects or generates corresponding models for traffic state prediction. The Markov model is developed based on historical traffic state transitions and is used to explain the stochastic evolutions of traffic states for each link.

The MLP package distinguishes different clusters and makes predictions under the selected clusters or scenarios to enhance prediction performance. The MLP Scenario Identifier module depends on the weather, roadwork, incidents, traffic control strategies, and traffic state data from data Store.

MLP Traffic Predictor

The MLP traffic predictor (MLPPredict) produces real-time, short-term traffic speed forecasts using the calibrated Markov transition matrices along with the most current traffic speed, work zone, incident, and weather data and a long time series of previous traffic speeds. The Predictor considers different transition probabilities between traffic states under different external conditions (e.g., weather, incident) and therefore is able to accurately predict traffic state evolution under specified scenarios. The Predictor can also consider the effects of different traffic control strategies (e.g., variable speed limit, contraflow) if they are available data for training.

MLPPredict modules are dependent on the data Store, a calibrated Markov model, and MLPUpdate modules that generate the long time series.

MLP Update Manager

The MLP update manager (MLPUpdate) creates the long time series of traffic speed data to be used in case of a gap in the live data feeds as part of real-time traffic speed predictions in the MLPPredict module. MLPUpdate modules are dependent on the data Store and a calibrated Markov model.

MLP Hurricane Assessment

The Machine Learning-based Prediction (MLP) Hurricane Traffic package predicts traffic speed given a set of network and hurricane variables, such as roadway link location, hurricane warning time and duration, hurricane intensity, and landfall location. MLP for hurricane traffic is a comprehensive data-driven prediction module that uses both the support vector machine model and the Markov process to characterize the evolution of traffic states under hurricane scenarios. The MLP package contains the MLP Hurricane Traffic Impact Identifier and Hurricane Traffic Predictor.

Input to the MLP package includes data from the data Store such as network environment, traffic speed, and hurricane forecast data. The outputs of the MLP package are the predicted traffic speeds for the selected time horizon (such as 6 hours, 1 day, 7 days).

MLP Hurricane Traffic Impact Identifier [Hurricane Traffic Impact Ident]

The MLP Hurricane Traffic Impact Identifier is a module within the MLP hurricane traffic package that contains two parts: an Impacted Links Identifier and a Markov Model Generator, both are computed from the archived data. The Impacted Links Identifier is a submodule that identifies the traffic state 1) on which links and 2) on what days after the hurricane warning would be impacted by the hurricane given the network geographic information and the forecasted hurricane conditions. The Markov Model is developed based on historical traffic state transitions and is used to explain the stochastic evolutions of traffic states for each impacted link.

This module uses an approach based on support vector machine (SVM) for impacted links identification. The SVM model is trained using the historical hurricane data, network environment data, and historical traffic data to indicate whether a significant speed drop took place for a specific link under a specific hurricane condition. The inputs for the SVM model are the aggregated speed data during historical hurricane periods. The trained SVM model is used to identify if traffic speed on a link would be significantly impacted by an upcoming hurricane given the network environment data and the forecasted hurricane data.

MLP Hurricane Traffic Predictor [Hurricane Traffic Predict]

The MLP Hurricane Traffic Predictor is a module within the MLP hurricane traffic package that predicts likely future network traffic states for a specified prediction horizon after the hurricane warning is issued (such as 1 hour, 2 hours, 1 day, 2 days, or 7 days) under specific network environment and hurricane conditions. The module contains two parts: a One-Shot Predictor and an Online Predictor. The One-Shot Predictor uses the traffic state data during historical hurricanes and the outputs from the Traffic Impact Identifier as model inputs to predict the future network states during the periods after the hurricane warning is issued. The Online Predictor uses real-time information on current network link traffic states and outputs of the One-Shot Predictor to predict future network states. The Predictor uses the time series model to account for the latest trends and observations from the field. Therefore, it is able to predict traffic state evolution under forecasted hurricane conditions and adjust the prediction based on real-time field observations and updated hurricane data. The MLP Hurricane Traffic Predictor depends on current network environment, hurricane, and traffic state data from the data Store and the outputs from the MLP Hurricane Traffic Impact Identifier. Particularly, both archived data and real-time feeds are used.

MLP Scenario Assessment

The Scenarios module uses the MLP Oneshot method to make long term speed predictions for roadway segments included in created scenarios. MLPProcess instances are dependent on the data Store, a calibrated MLP model, roadway segment definitions, and the Scenarios module.

COLLECT

The data collection (Collect) package collects data needed for IMRCP computations and forecast models. Collect modules depend on external systems for making the data available for collection. Collection interfaces, formats, and intervals are determined by the external data sources. The package is designed to be extensible and will accommodate new collection classes as new sources are identified and made accessible to the IMRCP. Know instances of Collectors include:

- ADCIRCEast for storm surge and tide forecasts
- AHPSFcst for hydrological forecasts
- AHPSObs for hydrological conditions
- CAP for alerts, watches, and warnings
- GFS for long term atmospheric weather forecasts
- LAc2c for real time traffic speeds
- LAc2cfEU for real time traffic incidents and work zones
- LADOTD511Line for real time and scheduled work zones
- LADOTD511Point for real time and scheduled work zones
- NDFDQpf for precipitation rate forecasts
- NDFDSky for cloud cover forecasts
- NDFDTd for dew point forecasts
- NDFDTemp for air temperature forecasts
- NDFDWspd for wind speed forecasts
- NHC for hurricane forecasts
- OhGoConstruction for real time and scheduled work zones
- OhGoIncidents for real time traffic incidents
- OhioInrix for real time traffic speeds
- Radar for observed radar reflectivity
- RadarPrecip for observed precipitation rates
- RAP for near and long term atmospheric weather forecasts
- RTMA for near term atmospheric weather observations
- WxDE for weather observations from ESS

STORE

The data Store package includes modules for containing and providing interfaces to all of the persistent data object classes in the system. It is critical to the overall objectives of the IMRCP that its functional modules and user interfaces use and present consistent data sets across all views of the system. A shared data Store fulfils this intent. Any data reused in multiple modules, including system evaluation, is preferentially maintained in the Store. Data in the Store are generally associated with a geodetic location which can be a polygon for atmospheric weather observations, a road segment for road weather or traffic observations, or a point for stationary or mobile ESS.

The data Store depends on data being provided by modules in the Collect and Computational packages. Virtually all other packages depend on the Store for access to the persistent data objects. These dependencies are described in each of the other packages.

FileCache

IMRCP collects and stores a wide variety or data types that have different temporal and spatial extents as well as storage formats. FileCache acts as the base class for all data stores and has generic functions for loading files in and out of memory and serving data through the getData function. Child classes use specific implementations of the FileWrapper class that understand how to read and create observations from the different file formats throughout the system. Known instances of the FileCache module include:

- ADCIRCStore
- AHPSFcstStore
- AHPSObsStore
- CAPStore
- GFSAlertsStore
- GFSPcCatStore
- GFSStore
- LADOTD511LineStore
- LADOTD511PointStore
- LADOTDEventsStore
- LaTrafficSpeedStore
- MetroStore
- MLPStoreLA
- MLPStoreOH
- MRMSPcCatStore
- NDFDPcCatAlertsStore
- NDFDPcCatStore
- NDFDQpfStore
- NDFDSkyStore
- NDFDTdStore
- NDFDTempStore
- NDFDWspdStore

- NHCStore
- OhGoConstructionStore
- OhGoIncidentsStore
- OhioTrafficSpeedStore
- RadarPrecipStore
- RadarStore
- RAPAlertsStore
- RAPPcCatAlertsStore
- RAPPcCatStore
- RAPStore
- RTMAStore
- TPVTDAStore
- TSSRFDAStore
- WxDEStore

ObsView

The Observation View module is the main endpoint for other modules within the system to request specific observation types from the data Store. Through the Directory, it knows the observation types that each store provides. The Observation View aggregates all the requested data from the individual stores and returns the observation objects to the requesting modules.

ProjProfiles

Geodetic information for observations and forecasts are stored in different projection coordinate systems throughout the data Store. To save memory and processing time, projection profiles are cached and shared between different data files. This singleton manages the creation and caching of the system's projection profiles.

SYSTEM

The System package provides the base system operating modules and utilities. These components are the first to be instantiated on system startup and provide services that enable other components to interact within the system.

Directory

The Directory is the main system component that initializes the system by identifying and managing BaseBlocks and services available within the system. Use of a Directory component enhances system extensibility and maintainability relative to a closed system.

Configuration [Config]

The Configuration component contains the configuration parameters for other system components and complements the Directory. Use of a Configuration component provides developmental and operational flexibility, theoretically enabling some system operating characteristics to be modified without stopping and restarting the system.

Scheduling

The Scheduling component provides scheduling services to other components in the IMRCP services-based architecture, much like a "Cron job" in a UNIX/Linux environment. The Scheduling and Configuration components work together to orchestrate the process-related operations of the system.

BaseBlock

IMRCP is a modular system with components that interact with each other. BaseBlock is the base class for any module that is managed by the Directory of the system and contains the necessary interfaces and member variables to operate within IMRCP.

ObsType

The ObsType class keeps track of the relationship between an observation type name and its internal system handle.

ExtMapping

The External Mapping component provides mapping and look up capabilities for system objects from external source to their corresponding IMRCP system object. This allows IMRCP to associate observations and forecasts from external systems to the correct system object inside of IMRCP.

COMP

The Computation (Comp) package contains modules that use algorithms to compute new observations and predictions based on other system observations and conditions. Modules in the computation package depend on the data Store to provide the necessary inputs for the different computational algorithms and models.

Alerts

Alerts modules can generate alerts for configured situations related to exceptional weather, hydrological, or traffic observations/predictions.

DataAssimilation

IMRCP uses algorithms based on observed and forecasted conditions to predict weather and roadway conditions for large areas. Some external data sources and types only provide limited spatial coverage of conditions. To be able to make predictions for the desired spatial extents in IMRCP, Data Assimilation techniques are used to combine a numerical model, namely a class of Kriging algorithms, with observations to have a more complete coverage of conditions. Currently these techniques are used to approximate surface and sub-surface temperatures across road networks using observed values from ESS.

EventComp

External sources that provide incident and roadwork data do not have a common standard or interface used to format and maintain active events. EventComp modules process the raw event data feeds to maintain a list of active events and save any updates to an event, including once the event is no longer active.

InrixComp

The data Store expects traffic speed data to be stored in a compact binary file. Since Inrix traffic speed data is received in multiple JSON files each collection cycle, the InrixComp module processes those files into the desired binary format.

Precipitation Category [PcCat]

Many weather forecast products provide precipitation forecasts as a category, instead of a numeric rate. IMRCP collects raw precipitation rate and precipitation type data from different sources, so to have easily understandable precipitation forecasts, rates and types are converted into categories.

LAc2cDetectors

The MLP traffic prediction model expects traffic speed data in 5 minute averages. Traffic speed data is collected every minute from the Louisiana C2C feed so the LAc2cDetectors computation module averages the speeds collected and saves the values in another file.

GEO SERVICES [GEOSRV]

The Geo Services (GeoSrv) package maintains the fundamental geographical description of the roadway system and its components..

WayNetworks

The WayNetworks module defines and describes the different deployment networks and all of the ways (roadway segments) contained in each network. A way is a set of two or more points called nodes. Metadata for each way, including number of lanes, speed limit, and elevation data, is also stored by the module.

DEM

Mapbox provides a raster tileset that contains global elevation data. The Mapbox Terrain-DEM contains raw height values stored in PNG tiles that can be decoded to raw heights in meters. To have access to the API, a Mapbox access token is required. IMRCP downloads and caches the elevation tiles on demand. The Digital Elevation Map (DEM) is used to lookup the elevation for a particular geo coordinate when the elevation is needed and not otherwise provided directly by a data source.

Mercator

Most open source and commercial Maps API providers use the Spherical Mercator projection coordinate system since it is easy to work with and preserves shapes and angles. Therefore IMRCP contains the Mercator module which provides convenience methods for converting lon/lat, Mercator, and map tile coordinates from one coordinate system to another.

OsmBz2ToBin

The definitions of roadway segments in IMRCP are derived from the Open Street Map database. OSM files for entire states can be downloaded in an XML format compressed by the bz2 algorithm. These files end up being very large and take a considerable time to open and process. Therefore IMRCP converts these files into a binary representation that is much more compact and faster to process.

OsmBinParser

OsmBinParser is used to load the files created by the OsmBz2ToBin class.

WEB

The Web package contains all of the components necessary to serve requests from the different webpages that make up the IMRCP user interface.

SecureBaseBlock

To ensure that only authorized users have access to the system and to prevent potential distributed denial-of-service (DDoS) attacks, SecureBaseBlock, a child class of BaseBlock, was developed with security algorithms to be used for every request made from the webpages.

NetworkGeneration

A robust and well defined roadway network is essential to a successful IMRCP deployment. To assist in the arduous task of creating a roadway network, a set of tools and algorithms were developed to help automate the task as much as possible.

SessMgr

Only authorized users with a valid session are allowed to access the system's user interfaces. SessMgr manages registered users, passwords, permissions, and browser sessions.

Scenarios

One of IMRCP's purposes is to assist in planning how to use resources during storms, scheduled maintenance, and rush hour traffic. To achieve this purpose, the Scenarios tool was developed, which allows users to create Scenarios and generate a 24 hour prediction for road conditions and traffic based on associating actions (plowing, chemical treatment, Variable Speed Limit change, and number of available lanes change) with segment groups.

Subscriptions

Subscriptions enables IMRCP to provide data reports and subscriptions to external systems and end users. One time reports can be helpful in analyzing past events while recurring subscriptions can be used to receive the most recent forecasts at a regular interval.

LayerServlet

Detailed data requests from the Map webpage are processed by different LayerServlets depending on the geographic extents of the request, which can be a single point, polyline (roadway segment), or polygon.

TileCache

Creating data views for data sets that cover large areas for the Map webpage can take a lot of processing time. To help alleviate processing burden and slow response times, the data views are tiled and cached by the server.

TileServlet

Creating data views for smaller data sets for the Map webpage can be done on the fly for each request. TileServlet components create data views for observations associated with a single point or roadway segment.

WEBPAGES

The webpages provide the primary user interfaces to the IMRCP system outputs. Only registered users have access and permission to use them. The WebPages package depends on the Web package for access to system data.

LogOn

The LogOn page is the first page users view when accessing IMRCP and allow them to submit their username and password to log into the system. It can also be used to display system messages, like scheduled maintenance times, to users.

Map

The Map provides a selectable, layered presentation of current and forecast traffic and weather conditions across the roadway network. A time control enables the user to change the time perspective being viewed on the map.

Create Scenario

The Create Scenario webpage provides a map interface to create and edit scenario templates which can then be given a name and reference time and submitted to process, generating a 24 hour prediction for road and traffic conditions.

View Scenarios

The View Scenarios webpage provides a map and table interface to view the 24 hour predictions for road and traffic conditions generated by a processed scenario.

Create Report

The Create Report webpage provides a map interface to create data reports and subscriptions.

View Reports

The View Report webpage provides a list interface to view and download available data files for reports and subscriptions.

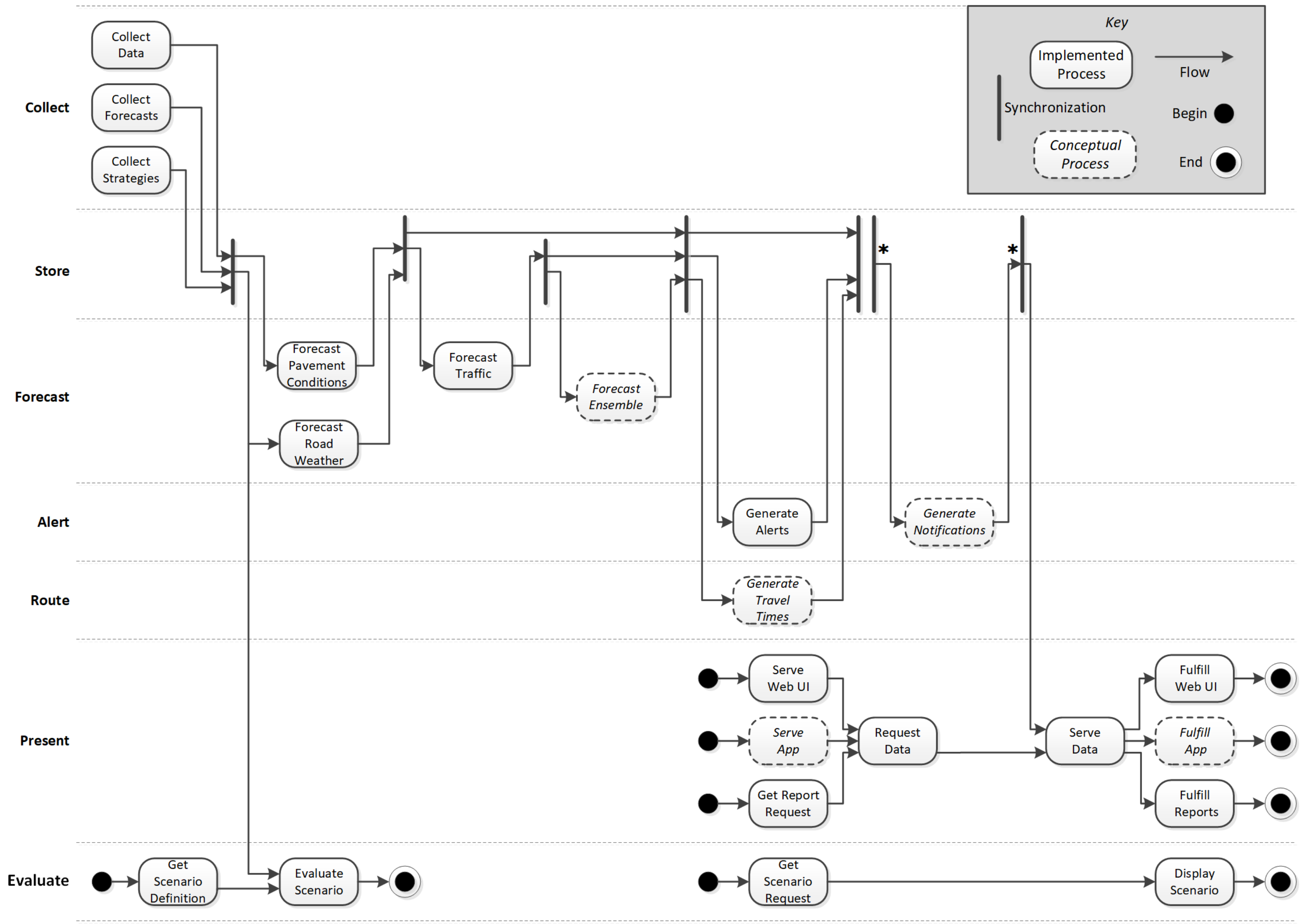
Network

The Network webpage provides a map interface to create and edit roadway networks. Only System Administrators have permission to access this page.

CHAPTER 6. PROCESS VIEW

The process view describes the system in terms of the flow of activities performed by the system. A Unified Modeling Language activity diagram is used to present an integrated high-level view as shown in Figure 2. “Swim lanes” are used to group the activities into general categories corresponding to the high-level functional objectives of the system.

The process view of the design generally derives from the functional description contained in the requirements. Activities performed by users or systems outside the IMRCP boundary are not included in the process descriptions. Activities and their relationships within the IMRCP are described below. Where appropriate, activities are further decomposed into sub-steps. The process view includes activities that are conceptually valuable, although they may not be implemented in the demonstration deployments.



(Source: FHWA)

Figure 2. Diagram. IMRCP Process

COLLECT DATA (OBSERVATIONS)

The IMRCP needs significant volumes of real-world data on which to base its forecasts. The Collect Observations process gathers information on current conditions observed across the phenomenological domains of interest (for example, weather, hydrology, traffic, and events). Although each domain typically has distinct data contributors, source systems and standard provisions, the process is relatively consistent across the domains. The locations, interface specifications, formats, types of data, and collection intervals are identified in configuration settings for each of the collection processes. The process itself consists of retrieving the data from the contributing systems, parsing the data to fit the internal IMRCP standard forms, and submitting the data to the Store. The process is implemented by modules within the Collect package.

COLLECT FORECASTS

Just as The IMRCP needs information on current conditions to set initial conditions for forecasts, it needs forecast and planned boundary conditions on which to base its own forecasts. The Collect Forecasts process gathers information on (boundary) conditions forecasted and planned across the phenomenological domains of interest (for example, atmospheric weather, hydrology, and events). As with the Collect Observations process, although each domain typically has distinct data contributors, source systems and standard provisions, the process is relatively consistent across the domains. The locations, interface specifications, formats, types of data and collection intervals are identified in configuration settings for each of the collection processes. The process itself consists of retrieving the data from the contributing systems, parsing the data to fit the internal IMRCP standard forms, and submitting the data to the Store. The process is implemented by modules within the Collect package.

COLLECT STRATEGIES

Forecasting future conditions depends on knowledge of how system agents interact with events as much as on initial and boundary conditions. These agent interactions may be called rules, plans, strategies or interventions; they differ from observations and forecasts in that they identify the potential for future actions based on system variables, rather than specifying future conditions. The Collect Strategies process gathers information on the bases for system control responses across the phenomenological domains of interest (for example, weather, hydrology, traffic and events). As with the condition and forecast collections, though each domain typically has distinct data contributors, source systems and standard provisions, the process is relatively consistent across the domains. The locations, interface specifications, formats, types of data and collection intervals are identified in configuration settings for each of the collection processes. The process itself consists of retrieving the data from the contributing systems, parsing the data to fit the internal IMRCP standard forms, and submitting the data to the Store. The process is implemented by modules within the Collect package.

FORECAST ROAD WEATHER

The Forecast Road Weather process imputes forecasts of road weather conditions from atmospheric weather forecasts for particular road segments. Conditions are allocated to particular segments based on the geodetic location of the segment relative to the gridded atmospheric forecast. The process is implemented by the RWF module.

FORECAST PAVEMENT CONDITION

The Forecast Pavement Condition process calculates pavement surface and subsurface conditions for each particular segment based on the imputed road weather forecast conditions and the observed pavement conditions. Initial pavement conditions for segments without direct observations are inferred from nearby observations. The process is implemented by the METRo module.

FORECAST TRAFFIC

The Forecast Traffic process generates predictions of traffic conditions on roadway segments. The process uses forecasts of atmospheric weather conditions, observations of current roadway weather conditions, and other information from the data Store, such as work zones and incidents, to compute forecasts of future roadway traffic conditions (MLP). The process consists of two subprocesses: Forecast Road Weather and Forecast Traffic Condition. The process is performed by modules within the Forecast package.

FORECAST ENSEMBLE

The Forecast Ensemble process generates consensus predictions of traffic conditions on the roadway segments and links. The process uses forecasts of predicted traffic conditions from the MLP packages to compute more confident forecasts of future roadway traffic conditions. The ensemble process itself uses prior predictions and observed conditions on roadway segments and links to adjust the weight the results of the independent forecast methods in creating the consensus result. The process is conceptually performed by modules within the Forecast package, but not implemented in IMRCP-4

GENERATE ALERTS

The Generate Alerts process observes current and predicted system conditions to synthesize alerts for use by other system components and eventual users. Generation of alerts is based on a set of rules in the form of logical statements about system conditions. For example, a “slick pavement” alert could be based on a measurement of ice on a roadway segment, or on an assessment of air temperature less than a configured threshold temperature with precipitation present along a roadway segment. The level of alert—advisory, watch, or warning—depends on the confidence and likelihood of the conditions. An observation or measurement of a condition would merit a warning, whereas an assessment based on future regional conditions might only warrant an advisory. The process is implemented by the Alert package.

GENERATE NOTIFICATIONS

The Generate Notifications process would conceptually notifications for alerts for users subscribed to those alerts. A notification process is based on a set of configurable rules that subscribe to particular alerts. Notifications may be associated with a geographic extent to which the notification applies and a temporal extent in which it is active. When a configured alert is present, a notification message is generated. The process is not implemented in IMRCP-4.

GENERATE TRAVEL TIMES

The Generate Travel Times process would conceptually compute travel times along routes based on current and predicted system conditions for use by other system components and eventual users. Routes and information about route conditions are generated from sets of links between an origin and a destination and characterized by distance, travel time, and, potentially, travel time reliability. Route characteristics are generated automatically for preconfigured routes based on high-volume OD pairs. The process is not implemented in IMRCP-4.

SERVE WEB USER INTERFACE

The Serve Web User Interface process provides web pages for user interaction in response to a web Uniform Resource Locator (URL) request. The web pages themselves will enable users to view the observation and forecast data and alerts. Any request for data entered by the user through this process is passed to the Request Data process. The process is implemented within the WebPages package.

GET REPORT REQUESTS

The Get Report Requests process provides an interface for users to request reports on and subscriptions to data from the system. Report and subscription requests are passed to the Request Data process for retrieval. The process is implemented within the WebPages package.

SERVE APPLICATION

The Serve Application process provides a web interface for mobile applications to interact with the IMRCP. The Serve Applications interface could provide the same types of information and user requests as provided through the web pages, with some optimization for smaller screens and more limited bandwidth. Any request for data entered by the user through this process is passed to the Request Data process. The process would be implemented through the App package, but is not implemented in IMRCP-4.

REQUEST DATA

The Request Data process takes input from the web, reports, and application services to fetch responses to user requests. The process is implemented by the Web package.

SERVE DATA

The Serve Data process structures and returns responses to user requests for IMRCP data and forecasts. Data are routed back to the interface that made the original request. The process is implemented by the Web package.

FULFILL WEB USER INTERFACE

The Fulfill Web User Interface process provides responses to user requests through the system's website. The web pages will then enable users to browse the results of their requests. The process is implemented within the WebPages package.

FULFILL REPORTS

The Fulfill Reports process returns the results of requests submitted by users to the IMRCP. Results are returned as links to files containing the report results. The process is implemented within the WebPages package.

FULFILL APPLICATION INTERFACE

The Fulfill Application Interface process returns the results of requests submitted by mobile applications to the IMRCP. The process is not implemented in IMRCP-4..

GET SCENARIO DEFINITION

The Get Scenario Definition process provides an interface by which a user creates a template for an operations scenario to be run against a background of weather conditions, traffic conditions, and weather forecasts. Operations to be considered include snowplowing, road treatment for snow and ice, variable speed limits, and increase or decrease in the number of lanes in use on a segment. The parameters of the scenario are saved and used in the Evaluate Scenario process. The process is implemented by the WebPages package.

EVALUATE SCENARIO

The Evaluate Scenario process executes forecasts for an operations scenario run against a background of weather conditions, traffic conditions, and weather forecasts. The process runs the scenario off-line and makes the outputs available for later user retrieval. The process is implemented by the Web package.

GET SCENARIO REQUEST

The Get Scenario Request process provides an interface by which a user requests the results of an operations scenario to run against a background of weather conditions, traffic conditions, and weather forecasts. The evaluation of a scenario is initiated in the Evaluate Scenario process. The process is implemented by the WebPages package.

DISPLAY SCENARIO

The Display Scenario process provides an interface by which a user views the results of an operations scenario to run against a background of weather conditions, traffic conditions, and weather forecasts. The process is implemented by the WebPages package.

CHAPTER 7. DEPLOYMENT VIEW

The deployment view describes the system in terms of the deployment of components to computing devices or nodes. A Unified Modeling Language deployment diagram may be used to represent the deployment. Packages defined in the composition view are allocated to computing devices in the deployment view. Nodes and their interconnections are described below.

This deployment of the IMRCP is a demonstration prototype. As such, the focus is on the development of models, and it is desirable to simplify the deployment in order to minimize system management overhead. To that end, the prototype is deployed as shown in Figure 3 to a single IMRCP environment. It provides distributed user access for the development team, the review team, and the partner prototype agency. Factors contributing to this configuration determination include:

- IMRCP data services and computational services are closely linked and benefit from co-location to reduce latencies and remote network calls.
- Other data sources (for example, atmospheric weather and hydrology) are provided by external web services that do not drive any particular deployment solution.
- Potential future phase operational deployments would be linked to TMCs and integrated management solutions. The bulk of the real-time operational and traffic data comes from transportation management systems, and the majority of the end users are either agency personnel or travelers for whom data is already sourced from TMCs and their associated systems. It makes sense within that context to anticipate and demonstrate a deployment as a set of forecast services rather than a distributed system.

This configuration will be subject to review and re-evaluation during development and deployment to assure the project and system needs are being met.

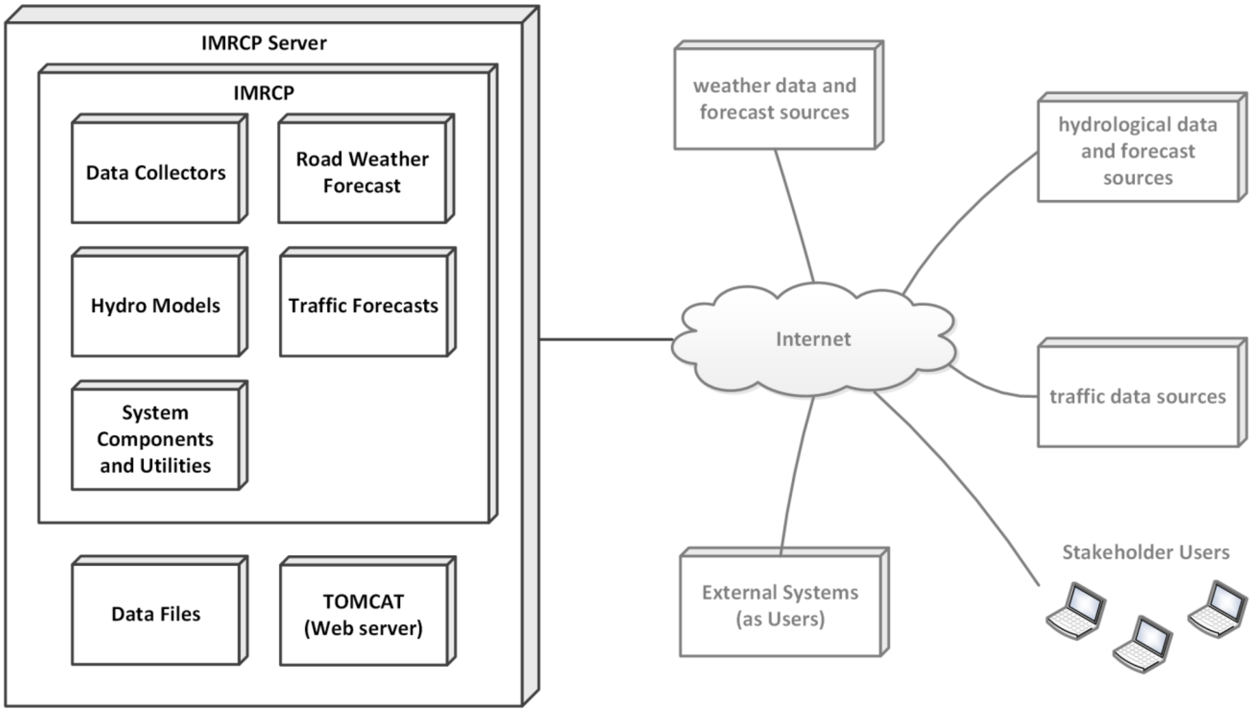


Figure 3. Diagram. IMRCP Deployment

(Source: FHWA)

CHAPTER 8. REFERENCES

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U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590

Office of Operations website
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