



**MET  
Research  
Group**

# **Multi-Agent Support Framework for Managing Children with Asthma Exacerbations in the Emergency Department**

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# Outline

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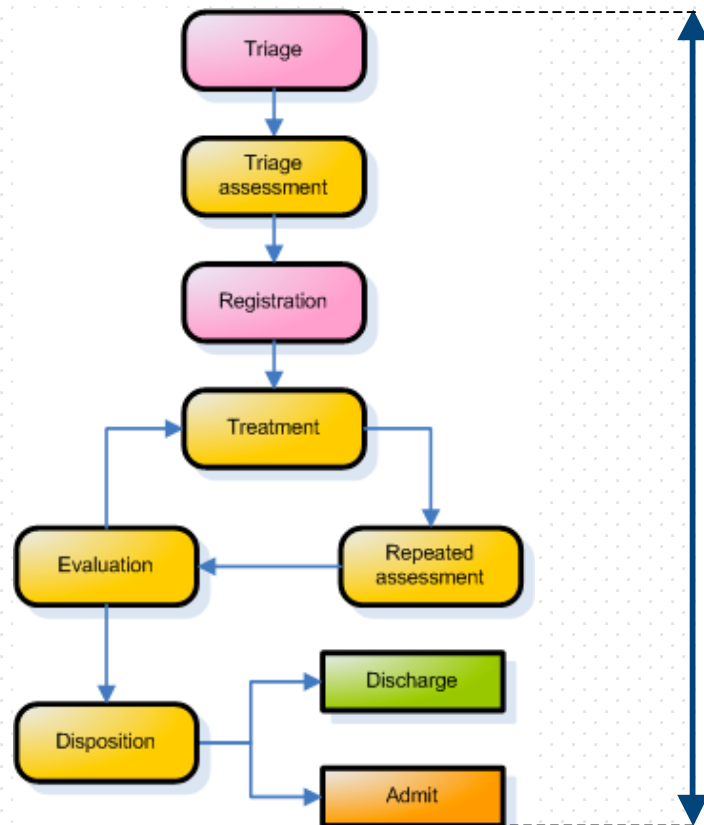
- Asthma in children and its management
- Issues and challenges
- Multi-agent systems
- A<sup>3</sup>Support
- Future research

# Asthma in Children

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- Asthma is a respiratory disease in which the airways constrict in response to some triggers (e.g., viruses, animal dander, dust)
- Asthma is the most common chronic disease in children (10% of Canadian population)
- Asthma exacerbations are the most common reasons for visits to the emergency department (ED)
- Asthma is expensive – children with asthma use 3 times more prescriptions, and require 2 times as many ambulatory care and ED visits as other pediatric patients

# Management Workflow of Asthma Exacerbations



Severity	Duration
Mild	≤ 4 hours
Moderate	4 – 12 hours
Severe	12 – 16 hours

- Underestimation of the severity results in premature discharge and a possible return visit
- Overestimation of the severity results in patients unnecessarily occupying beds and clinical resources

# Current Management Tools (1)

- Paper-based tools and forms
- No direct support for evidence-based decision making

**CHEO** Children's Hospital of Eastern Ontario  
Centre hospitalier pour enfants de l'est de l'Ontario  
**EMERGENCY TRIAGE ASSESSMENT RECORD**

Date: \_\_\_\_\_ Time: \_\_\_\_\_

Name: \_\_\_\_\_

Chief complaint: \_\_\_\_\_

Pre hospital: T \_\_\_\_\_ °C HR \_\_\_\_\_ R \_\_\_\_\_ BP \_\_\_\_\_ SaO<sub>2</sub> \_\_\_\_\_ glucose \_\_\_\_\_  
 O<sub>2</sub>  IV/lock  board  collar  sling  splint  dressing

Last dose of:  Acetaminophen at \_\_\_\_\_ hrs  Ibuprofen at \_\_\_\_\_ hrs

History: \_\_\_\_\_

Temp \_\_\_\_\_ °C  O  R  A P \_\_\_\_\_ R \_\_\_\_\_ BP \_\_\_\_\_ SaO<sub>2</sub> \_\_\_\_\_ wt \_\_\_\_\_ KGS

Allergies  No  Yes Medications  No  Yes Immunized  Yes  No  Unknown Sickle Status  negative  positive  trait  unknown

CARDIO / RESPIRATORY	NEUROLOGICAL	GI / GU	TRAUMA/INJURY
<b>Colour</b> <input type="checkbox"/> pink <input type="checkbox"/> pale <input type="checkbox"/> pale/normal for child <input type="checkbox"/> mottled <input type="checkbox"/> cyanosed <input type="checkbox"/> jaundiced cap refill: <input type="checkbox"/> < 2 sec <input type="checkbox"/> > 2 sec <b>Work of breathing</b> <input type="checkbox"/> no apparent distress <input type="checkbox"/> ↑ rate <input type="checkbox"/> ↑ effort <input type="checkbox"/> nasal flaring <input type="checkbox"/> tracheal tug <input type="checkbox"/> retractions <input type="checkbox"/> grunting (R) <b>Breath sounds</b> (L) <input type="checkbox"/> clear <input type="checkbox"/> stridor <input type="checkbox"/> diminished <input type="checkbox"/> crackles <input type="checkbox"/> wheezing <input type="checkbox"/> cough <input type="checkbox"/> history of asthma <input type="checkbox"/> difficulty swallowing <input type="checkbox"/> croup score _____ <input type="checkbox"/> asthma score _____	<input type="checkbox"/> alert <input type="checkbox"/> engageable <input type="checkbox"/> consolable <input type="checkbox"/> asleep/arousable <input type="checkbox"/> drowsy <input type="checkbox"/> irritable <input type="checkbox"/> lethargic <input type="checkbox"/> unresponsive Pupils: <input type="checkbox"/> normal (PERBL) <input type="checkbox"/> abnormal Describe: _____ size _____ mm Coma scale: _____ / 15 Fontanelle: <input type="checkbox"/> normal <input type="checkbox"/> bulging <input type="checkbox"/> high pitched or moaning cry <input type="checkbox"/> headache <input type="checkbox"/> LOC <input type="checkbox"/> unknown <input type="checkbox"/> vomiting _____ x's <input type="checkbox"/> amnesia <input type="checkbox"/> weakness <input type="checkbox"/> numbness _____	<input type="checkbox"/> abdominal pain <input type="checkbox"/> scrotal pain <input type="checkbox"/> vomiting _____ x/ 24hrs <input type="checkbox"/> diarrhea _____ x/ 24hrs Lips <input type="checkbox"/> moist <input type="checkbox"/> dry Mouth <input type="checkbox"/> moist <input type="checkbox"/> dry Eyes <input type="checkbox"/> normal <input type="checkbox"/> sunken Fontanelle: <input type="checkbox"/> normal <input type="checkbox"/> sunken Skin turgor <input type="checkbox"/> normal <input type="checkbox"/> decreased <input type="checkbox"/> tented Last voided _____ hrs Last normal BM _____ LMP _____ Urine: <input type="checkbox"/> bagged <input type="checkbox"/> self <input type="checkbox"/> parent <input type="checkbox"/> police <input type="checkbox"/> worker <input type="checkbox"/> other <input type="checkbox"/> requested <input type="checkbox"/> obtained	<input type="checkbox"/> skin intact <input type="checkbox"/> pulse present <input type="checkbox"/> ↓ ROM <input type="checkbox"/> swelling <input type="checkbox"/> ecchymosis <input type="checkbox"/> pt tenderness <input type="checkbox"/> deformity <input type="checkbox"/> tingling <input type="checkbox"/> numbness <input type="checkbox"/> cap refill (< 2 sec)
			<b>Pain Assessment</b> Modified pain faces 0 2 4 6 8 10 Numeric pain scale 0 1 2 3 4 5 6 7 8 9 10
			<b>Interventions</b> <input type="checkbox"/> eye patch <input type="checkbox"/> collar <input type="checkbox"/> board <input type="checkbox"/> sling <input type="checkbox"/> splint <input type="checkbox"/> ice <input type="checkbox"/> elevation <input type="checkbox"/> wheelchair <input type="checkbox"/> stretcher Wound care: <input type="checkbox"/> cleansed <input type="checkbox"/> dry <input type="checkbox"/> dsg <input type="checkbox"/> saline <input type="checkbox"/> dsg <input type="checkbox"/> NPO <input type="checkbox"/> sent to x-ray
<input type="checkbox"/> suicidal attempt requiring medical attention <input type="checkbox"/> recent onset of hallucinations / bizarre behaviour <input type="checkbox"/> other mental health/psychosocial issues <input type="checkbox"/> violent upon arrival <input type="checkbox"/> agitated <input type="checkbox"/> restrained <input type="checkbox"/> risk to himself or others (reported by _____)		Arrived with: <input type="checkbox"/> self <input type="checkbox"/> form 1 <input type="checkbox"/> form 2 <input type="checkbox"/> parent <input type="checkbox"/> police <input type="checkbox"/> worker <input type="checkbox"/> other	
Disposition: <input type="checkbox"/> Resus <input type="checkbox"/> WR <input type="checkbox"/> SWR <input type="checkbox"/> chairs <input type="checkbox"/> isolation <input type="checkbox"/> assessment <input type="checkbox"/> exam room # _____ <input type="checkbox"/> CHC <input type="checkbox"/> PIC (notified) <input type="checkbox"/> Paged at _____ hrs <input type="checkbox"/> CIW available <input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> See pathway/ RAD form <input type="checkbox"/> old chart <input type="checkbox"/> called <input type="checkbox"/> CIW informed or message left at _____ hrs <input type="checkbox"/> recent ER visit _____ days ago			
RN's signature: _____ Student's signature: _____			TRIAGE CATEGORY: R E U S R

Form No. 1121 (9018), Rev. Feb 2005

# Current Management Tools (2)

**CHEO** Children's Hospital of Eastern Ontario  
Centre hospitalier pour enfants de l'est de l'Ontario

### INITIAL PHYSICIAN ORDERS FOR ASTHMA CRITICAL PATHWAY IN THE EMERGENCY DEPARTMENT

Weight: \_\_\_\_\_ kg Height: \_\_\_\_\_ cms Allergies: \_\_\_\_\_

**START ASTHMA CRITICAL PATHWAY IN THE EMERGENCY DEPARTMENT**

Pediatric droplet precautions

**TEST**

PFT (pt ≥ 6 years old)

Other: \_\_\_\_\_

**TREATMENT / MEDICATION**

Salbutamol metered-dose inhaler (Ventolin MDI) 100mcg/puff with spacer as indicated by weight q \_\_\_\_\_

< 6 kg = 2 puffs  26-34 kg = 8 puffs

6-18 kg = 4 puffs  > 34 kg = 10 puffs

19-25 kg = 6 puffs

Salbutamol nebuler (Ventolin) by inhalation as indicated by weight q \_\_\_\_\_

3-6 kg = 1/2 of a 1.25 mg / 2.5 mL nebuler (quantity sufficient to 3mL with Normal Saline)

> 6-12 kg = 1.25 mg / 2.5 mL nebuler

> 12-20 kg = 2.5 mg / 2.5 mL nebuler

> 20 kg = 5 mg / 2.5 mL nebuler

Ipratropium Bromide meter-dose inhaler (Atrovent MDI) 20mcg/puff with spacer 2 puffs q \_\_\_\_\_

Ipratropium Bromide (Atrovent) 250 mcg/mL for inhalation

0.5 mL for age < 1 year old q \_\_\_\_\_  1 mL for age > 1 year old q \_\_\_\_\_

Dexamethasone \_\_\_\_\_ mg PO x 1 dose (0.15-0.3 mg/kg/dose; MAX: 12 mg/dose)

Prednisone \_\_\_\_\_ mg PO x 1 dose (1-2 mg/kg/dose; MAX: 60 mg/dose)

Acetaminophen \_\_\_\_\_ mg (10-15 mg/kg/dose) PO / PR q 4-6 hr prn (MAX: 60 mg/kg/day)

Ibuprofen \_\_\_\_\_ mg (10 mg/kg/dose) PO q 6-8 hr prn (MAX: 40mg/kg/day)

Other: \_\_\_\_\_

**HYDRATION**

IV \_\_\_\_\_ at \_\_\_\_\_ mL/hr

IV \_\_\_\_\_ mL over \_\_\_\_\_ minutes

**CONSULT**

ICU  Social Work Service  Chest Clinic  Other: \_\_\_\_\_

**OTHER**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

NARCOTICS - 48 HR STOP ORDER POLICY

PHYSICIAN SIGNATURE \_\_\_\_\_ PRINT NAME OF PHYSICIAN \_\_\_\_\_ DATE & TIME \_\_\_\_\_

NURSE SIGNATURE \_\_\_\_\_ PRINT NAME OF NURSE \_\_\_\_\_ DATE & TIME \_\_\_\_\_

Original Copy - Chart      Yellow Copy - Pharmacy

Form No. 1224, Jan 2005,  
Approved by P & T Nov 23, 2004

**CHEO** Emergency Department  
**ASTHMA CRITICAL PATHWAY**

*Critical pathways are not a substitute for sound professional judgement*

Documentation Codes:  = Completed / With normal limits  
N/A or  = Not Applicable  = Significant findings documented on back

DATE: \_\_\_\_\_ START TIME: \_\_\_\_\_ Night Day Evening

**Expected Outcomes**

- Decrease resp. distress, none-mild
- O<sub>2</sub> saturation > 95% in room air
- Well hydrated and tolerating po fluid
- Good understanding of education

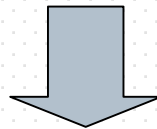
Aspect of care	Code	Initials	Code	Initials	Code	Initials
<b>1 Assessment</b> Chest assessment pre-post treatment Temp, RR & HR q 2-4 hours and prn O <sub>2</sub> saturation prn						
<b>2 Tests</b> Auger suction for virology if admitted PFT (pt > 6 years old) as ordered						
<b>3 Treatment / Medications</b> Oxygen to keep O <sub>2</sub> saturation > 92% Salbutamol MDI with spacer as ordered Salbutamol by inh as per medical directive/order Ipratropium MDI with spacer as ordered Ipratropium by inh as per medical directive/order Dexamethasone / Prednisone daily as ordered Antipyretic as per medical directive/order						
<b>4 Activity</b> AAT						
<b>5 Hydration</b> DAT - encourage oral intake Intake & output prn I.V. as ordered D/C IV prior to discharge						
<b>6 Education</b> Asthma Care Pathway pamphlet reviewed Asthma booklet given Device : age appropriate, technique, care & pamphlet Medication : why, when and how						
<b>7 Consults</b> ICU / Social Work Service / Chest Clinic as ordered						
<b>8 Discharge Planning</b> Expected outcomes met ED Discharge Info sheet given Action Plan given and reviewed prn						
<b>Pre-Assessment</b>	Time					
	Temp					
	RR					
	HR					
	O <sub>2</sub> *					
	Flow rate					
	O <sub>2</sub> saturation					
	Exp. wheeze					
	Insp. wheeze					
	Retractions					
Air Entry						
Color						
Medication(s)*						
INITIALS						
<b>Post-Assessment</b>	Time					
	Temp					
	RR					
	HR					
	O <sub>2</sub> saturation					
	Exp. wheeze					
	Insp. wheeze					
	Retractions					
	Air entry					
	PT respond to tx? (Y / N)					
INITIALS						

Form No.3029, Rev Dec '04      \*KEY: Medications: Ventolin (V); Atrovent (A)      O2: Nasal Prong (N); Mask (M); Tent (T)

# Future Management Tools

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- Paper charts and forms replaced by hospital information systems (HIS) including
  - Electronic health record (EHR)
  - Laboratory information system (LIS)
  - Computer physician order entry (CPOE)
  - Admission-discharge-transfer (ADT)
- Availability of the wireless network throughout the ED

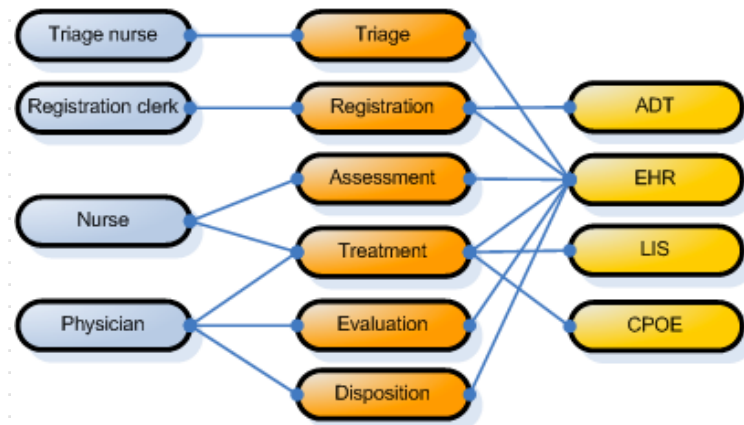


- An opportunity to introduce a clinical decision support system (CDSS) for managing asthma exacerbations

# Issues and Challenges

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- Different users complete diversified tasks from the management workflow using different information systems



- Interactions with multiple systems
- No support for evidence-based decision making
- Lack of uniform security and privacy solutions



# Security and Privacy Issues

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- Legal framework provided by PHIPA – Personal Health Information Protection Act
- The "circle of care"
  - Defines members of the health care team who are involved in providing care or treatment to a particular patient
  - Members of a "circle of care" can collect and use the patient's personal health information for that care, unless they know that the patient has expressly withheld or withdrawn consent
- "Lock boxes"
  - Patient has right to have his/her health information withheld from the members of a circle of care

# Multi-Agent Architecture

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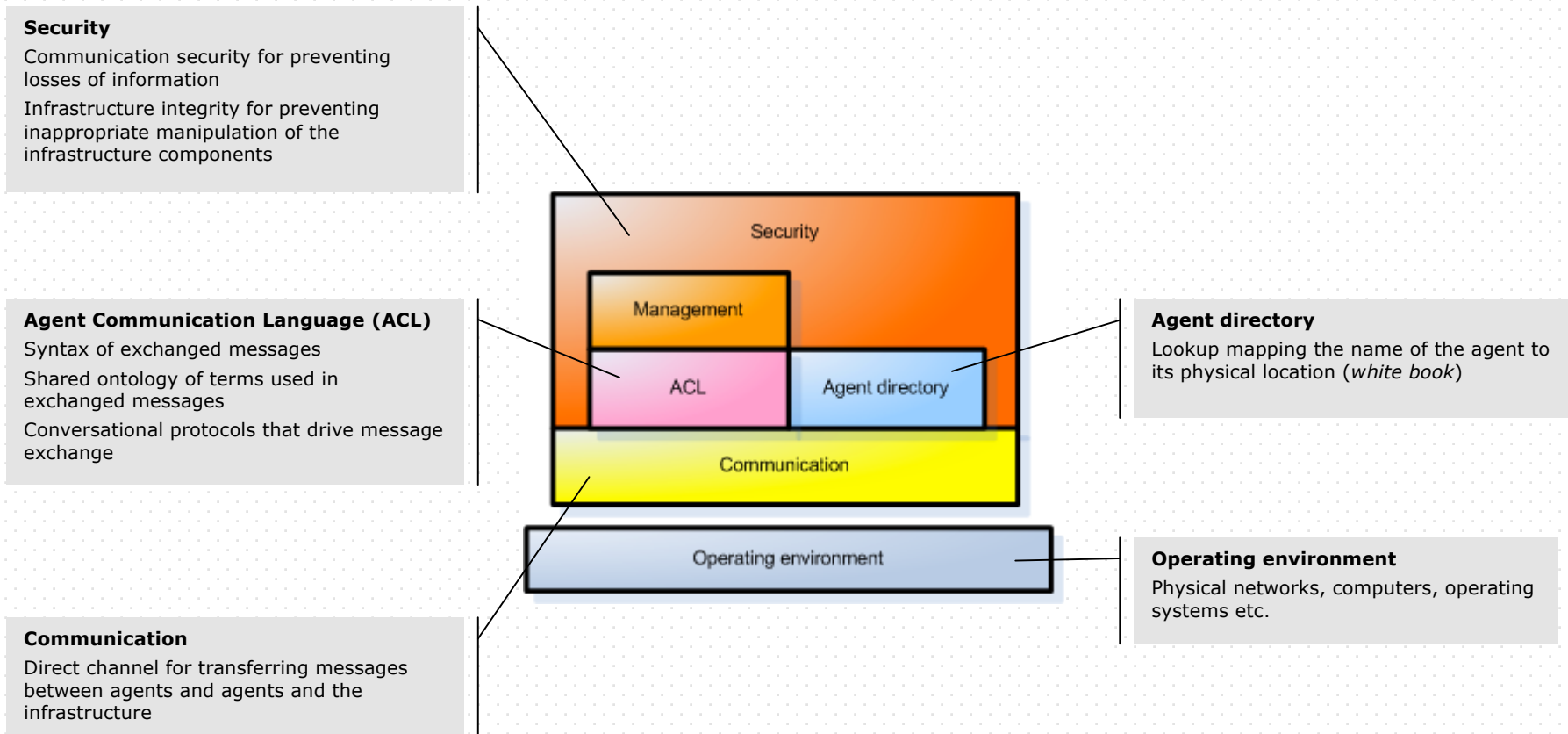
- Multi-agent system is composed of several software agents, collectively capable of solving problems
- Proposed approach is inspired by RETSINA (Reusable Environment for Task-Structured Intelligent Networked Agents) developed at Carnegie-Mellon University
- RETSINA has three levels of architecture
  - Infrastructure architecture
  - Functional architecture
  - Agent architecture
- RETSINA does not rely on a "coordinator" and uses capability-based coordination to coordinate the agents

# A<sup>3</sup>Support System Architecture

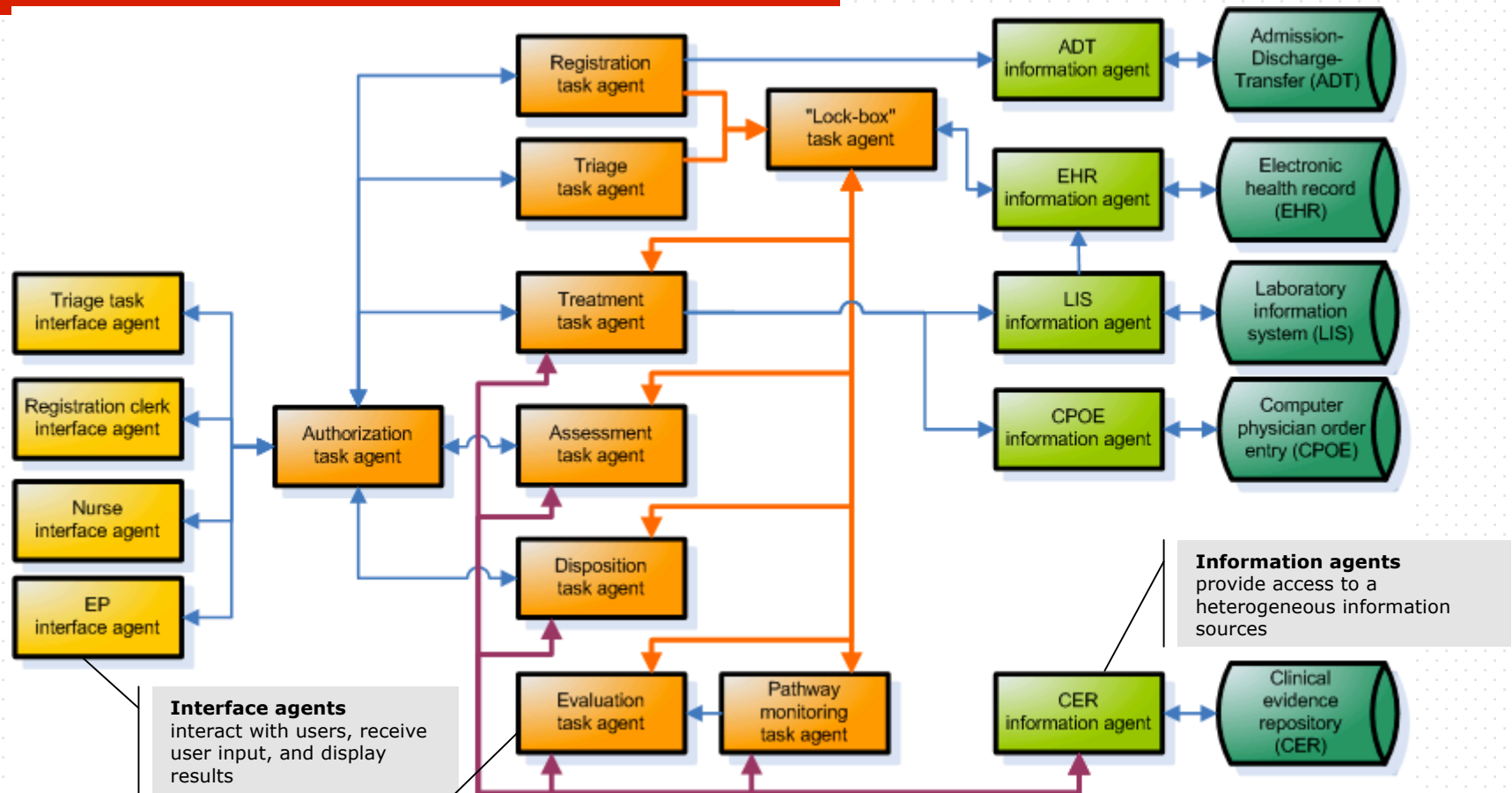
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- A<sup>3</sup>Support: providing support **A**n anytime **A**nd **A**n anywhere
  
- Structure of the system reflects the management workflow
  - Each user group has corresponding **interface agent**
  - Each patient management task has corresponding **task agent**
  - Each hospital system has corresponding **information agent**
  
- Additional components
  - Clinical evidence repository (CER) with information agent
  - "Circle of care" – access of authorized users with task agent
  - "Lock boxes" – access to authorized information with task agent

# A<sup>3</sup>Support Infrastructure Architecture



# A<sup>3</sup>Support Functional Architecture

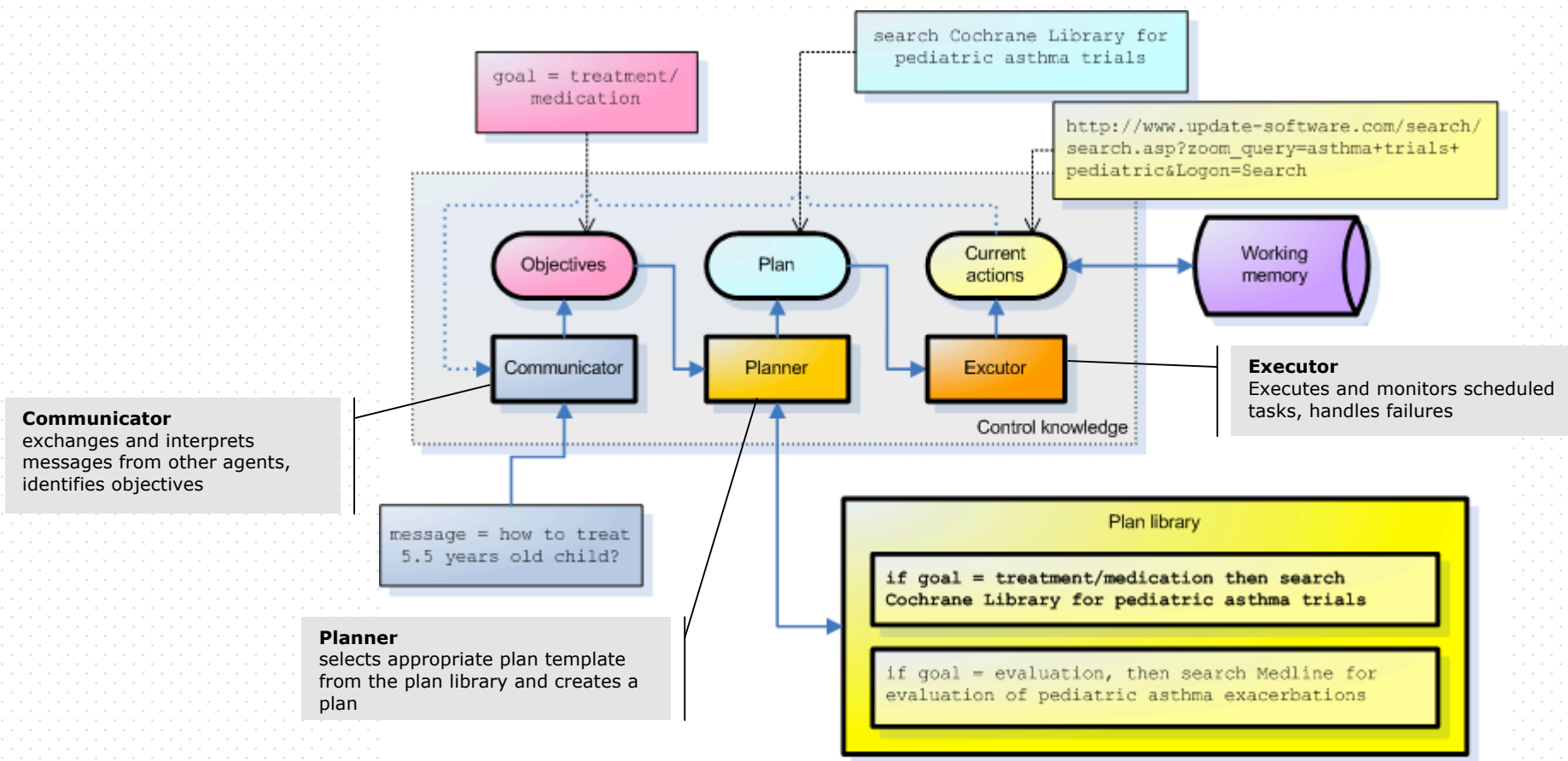


**Interface agents** interact with users, receive user input, and display results

**Task agents** help users perform tasks, formulate problem-solving plans and execute these plans

**Information agents** provide access to a heterogeneous information sources

# A<sup>3</sup>Support Agent Architecture



# Future Research

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- ❑ ACL and shared ontologies
- ❑ Computer implementation of A<sup>3</sup>Support
- ❑ Integration with existing hospital systems and data exchange methods
- ❑ Provision of meaningful evidence for decision support
- ❑ Prospective evaluation of clinical performance

# Thank You

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