

# Competition - Restaurant Staffing Crisis

## Management Science - La Étoile Three-Star Restaurant

### Client Briefing

La Étoile, our three-Michelin-star restaurant, faces a staffing crisis this weekend.

### The Situation

"I need to schedule my 18 servers across 6 shifts this weekend. The problem? My experienced servers cost €75/hour while juniors cost only €25/hour. But it gets worse! Shifts have different lengths (4-6 hours), servers have strong preferences about when they can work, and if I don't have enough experienced servers on busy shifts, we face penalties ranging from €0 to €1,200 per missing experienced server from our parent company!"

### The Challenge

You have multiple competing objectives. You need more experienced servers than available, shifts have different lengths affecting labor costs, and servers have varying preferences for different shifts. Critically, some servers cannot work certain shifts due to personal commitments (shown as preference = 0). Your job is to find the best compromise:

- Minimize total cost (labor + experience penalties + preference penalties)
- Respect hard availability constraints (preference = 0 means CANNOT work that shift)
- Balance multiple factors: shift coverage, server happiness, and costs
- Strategic decisions: which expensive penalties to accept?
- Navigate interdependencies created by availability constraints

#### 💡 Tip

Fortunately, La Étoile has already clearly quantified the weight of all objectives for you, so you don't need to involve a pareto frontier in the optimization process.

### Your Resources

- 6 Experienced Servers (€75/hour)
- 12 Junior Servers (€25/hour)
- 6 Shifts to cover (3 servers each)
- Everyone works exactly one shift

### The Data

```

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import random
from typing import Dict, List, Tuple

# Set seeds
np.random.seed(2025)
random.seed(2025)

# Server data
servers = pd.DataFrame({
    'Server_ID': [f'E{i:02d}' for i in range(1, 7)] + [f'J{i:02d}' for i in range(1, 13)],
    'Type': ['Experienced'] * 6 + ['Junior'] * 12,
    'Hourly_Rate': [75] * 6 + [25] * 12,
    'Name': ['François', 'Amélie', 'Baptiste', 'Céline', 'Damien', 'Élise'] +
        ['Jules', 'Margot', 'Théo', 'Camille', 'Léa', 'Hugo',
         'Emma', 'Louis', 'Chloé', 'Lucas', 'Manon', 'Ethan']
})
# Shift data with varying lengths - Weekend coverage
shifts = pd.DataFrame({
    'Shift_ID': ['FD', 'FL', 'SL', 'SD', 'UL', 'UD'],
    'Shift_Name': ['Friday Dinner', 'Friday Late', 'Saturday Lunch',
                   'Saturday Dinner', 'Sunday Lunch', 'Sunday Dinner'],
    'Day': ['Friday', 'Friday', 'Saturday', 'Saturday', 'Sunday',
            'Sunday'],
    'Time': [['18:00-00:00', '23:00-03:00', '11:00-15:00',
              '17:00-21:00', '11:00-16:00', '17:00-22:00'],
             ],
    'Hours': [6, 4, 4, 4, 5, 5],
    'Required_Servers': [3, 3, 3, 3, 3, 3],
    'Min_Experienced': [2, 0, 1, 2, 1, 2], # 8 needed, 6 available =
shortage of 2!
    'Expected_Covers': [120, 40, 80, 140, 90, 130], # Number of guests
    'Penalty_Per_Missing': [800, 0, 500, 1200, 600, 1000] # Penalties!
})
# Server preferences (0 = CANNOT WORK, 1-10 = preference level)
np.random.seed(2025)
preferences = {}

# Hard availability constraints (0 = cannot work this shift)
unavailable = {
    # Experienced server constraints
    'E01': ['FD', 'UL', 'SL', 'FL'], # François: Can work SD, UD only
    'E02': ['UD', 'UL', 'SL', 'FL'], # Amélie: Can work SD, FD, FL only
    'E03': ['SD', 'FD', 'SL', 'FL'], # Baptiste: Can work UD, UL, FL only
    'E04': ['SD', 'SL', 'UL', 'FL'], # Céline: Can work FD, UD only
    'E05': ['SD', 'SL', 'UL', 'FL'], # Damien: Can work FD, UD only
    'E06': ['FD', 'UL', 'SL', 'FL'], # Élise: Can work SD, UD, FL only
    # Junior constraints
}

```

```

'J02': ['SD', 'UD', 'FD'],
'J05': ['SD', 'UD', 'FD'],
'J08': ['SD', 'UD', 'FD'],
}

for _, server in servers.iterrows():
    server_prefs = []
    for _, shift in shifts.iterrows():
        # Check hard constraints first
        if server['Server_ID'] in unavailable and shift['Shift_ID'] in unavailable[server['Server_ID']]:
            pref = 0 # CANNOT WORK
        else:
            # Generate preferences based on server type
            if server['Type'] == 'Experienced':
                if 'Dinner' in shift['Shift_Name']:
                    pref = np.random.choice([5, 7, 8, 9, 10], p=[0.1, 0.2,
0.3, 0.3, 0.1])
                elif 'Late' in shift['Shift_Name']:
                    pref = np.random.choice([1, 2, 3, 4, 5], p=[0.2, 0.3,
0.2, 0.2, 0.1])
                else: # Lunch
                    pref = np.random.choice([3, 4, 5, 6, 7], p=[0.1, 0.2,
0.3, 0.3, 0.1])
                else: # Junior servers
                    if 'Late' in shift['Shift_Name']:
                        pref = np.random.choice([4, 6, 7, 8, 9], p=[0.1, 0.2,
0.2, 0.3, 0.2])
                    elif 'Lunch' in shift['Shift_Name']:
                        pref = np.random.choice([3, 5, 6, 7, 8], p=[0.1, 0.2,
0.3, 0.3, 0.1])
                    else: # Dinner
                        pref = np.random.choice([2, 4, 5, 6, 7], p=[0.1, 0.2,
0.3, 0.3, 0.1])
            server_prefs.append(pref)
    preferences[server['Server_ID']] = server_prefs

# Create preference matrix
pref_matrix = pd.DataFrame(preferences, index=shifts['Shift_ID']).T
print("\n\nSERVER PREFERENCES (0=CANNOT WORK, 1=hates it, 10=loves it):")
print("=" * 60)
print(pref_matrix.to_string())
print("\nAvailability Constraints:")
for server_id, shifts_unavailable in unavailable.items():
    server_name = servers[servers['Server_ID'] == server_id].iloc[0]
    print(f" {server_name} ({server_id}): Cannot work {',
'.join(shifts_unavailable)}")

print("SERVERS AVAILABLE:")
print("=" * 60)
print(servers.to_string(index=False))

print("\n\nSHIFT REQUIREMENTS:")

```

```

print("=" * 60)
print(shifts.to_string(index=False))

print("\n\nTHE PROBLEM:")
print("=" * 60)
print(f"Total experienced servers needed:  
{shifts['Min_Experienced'].sum()}")
print(f"Total experienced servers available: {(servers['Type'] ==  
'Experienced').sum()}")
print(f"SHORTAGE: {shifts['Min_Experienced'].sum() - (servers['Type'] ==  
'Experienced').sum()} experienced servers!")
print("\nComplex factors:")
print(" • HARD CONSTRAINTS: Some servers cannot work certain shifts  
(pref=0)")
print(" • Varying shift lengths (4-6 hours) affect total labor cost")
print(" • Large penalty amounts (€500-€1200) make choices strategic")
print(" • Server preferences (1-10) affect morale and quality")
print(" • Lower preferences = unhappy staff = significant quality penalty")
print(" • Availability constraints create interdependencies between  
assignments")

```

SERVER PREFERENCES (0=CANNOT WORK, 1=hates it, 10=loves it):

=====

Shift_ID	FD	FL	SL	SD	UL	UD
E01	0	0	0	7	0	9
E02	10	0	0	8	0	0
E03	0	0	0	0	5	7
E04	9	0	0	0	0	8
E05	10	0	0	0	0	9
E06	0	0	0	8	0	9
J01	2	8	3	4	7	7
J02	0	7	5	0	7	0
J03	7	7	5	7	8	4
J04	5	6	3	5	8	5
J05	0	9	3	0	5	0
J06	5	8	8	5	8	5
J07	6	9	6	6	5	5
J08	0	6	6	0	7	0
J09	6	6	6	2	8	7
J10	4	9	6	4	7	5
J11	7	8	8	7	5	5
J12	6	8	6	6	7	6

Availability Constraints:

François (E01): Cannot work FD, UL, SL, FL  
 Amélie (E02): Cannot work UD, UL, SL, FL  
 Baptiste (E03): Cannot work SD, FD, SL, FL  
 Céline (E04): Cannot work SD, SL, UL, FL  
 Damien (E05): Cannot work SD, SL, UL, FL  
 Élise (E06): Cannot work FD, UL, SL, FL  
 Margot (J02): Cannot work SD, UD, FD

Léa (J05): Cannot work SD, UD, FD

Louis (J08): Cannot work SD, UD, FD

SERVERS AVAILABLE:

Server_ID	Type	Hourly_Rate	Name
E01	Experienced	75	François
E02	Experienced	75	Amélie
E03	Experienced	75	Baptiste
E04	Experienced	75	Céline
E05	Experienced	75	Damien
E06	Experienced	75	Élise
J01	Junior	25	Jules
J02	Junior	25	Margot
J03	Junior	25	Théo
J04	Junior	25	Camille
J05	Junior	25	Léa
J06	Junior	25	Hugo
J07	Junior	25	Emma
J08	Junior	25	Louis
J09	Junior	25	Chloé
J10	Junior	25	Lucas
J11	Junior	25	Manon
J12	Junior	25	Ethan

SHIFT REQUIREMENTS:

Shift_ID	Shift_Name	Day	Time	Hours	Required_Servers
	Min_Experienced	Expected_Covers	Penalty_Per_Missing		
	FD	Friday Dinner	Friday 18:00-00:00	6	3
2		120	800		
0	FL	Friday Late	Friday 23:00-03:00	4	3
		40	0		
1	SL	Saturday Lunch	Saturday 11:00-15:00	4	3
2		80	500		
2	SD	Saturday Dinner	Saturday 17:00-21:00	4	3
1		140	1200		
1	UL	Sunday Lunch	Sunday 11:00-16:00	5	3
2		90	600		
2	UD	Sunday Dinner	Sunday 17:00-22:00	5	3
		130	1000		

THE PROBLEM:

Total experienced servers needed: 8

Total experienced servers available: 6

SHORTAGE: 2 experienced servers!

Complex factors:

- HARD CONSTRAINTS: Some servers cannot work certain shifts (pref=0)
- Varying shift lengths (4-6 hours) affect total labor cost
- Large penalty amounts (€500-€1200) make choices strategic
- Server preferences (1-10) affect morale and quality

- Lower preferences = unhappy staff = significant quality penalty
- Availability constraints create interdependencies between assignments

## Understanding the Costs

```
# Visualize the requirements and cost impacts
fig, axes = plt.subplots(2, 2, figsize=(14, 10))

# Top Left: Shift requirements
ax = axes[0, 0]
x = range(len(shifts))
width = 0.35
ax.bar([i - width/2 for i in x], shifts['Required_Servers'], width,
       label='Total Needed', color='gray', alpha=0.7)
ax.bar([i + width/2 for i in x], shifts['Min_Experienced'], width,
       label='Experienced Needed', color='red', alpha=0.7)
ax.set_xlabel('Shift')
ax.set_ylabel('Number of Servers')
ax.set_title('Server Requirements by Shift')
ax.set_xticks(x)
ax.set_xticklabels(shifts['Shift_ID'])
ax.legend()
ax.axhline(y=6, color='green', linestyle='--', label='Available Experienced')
ax.text(2.5, 6.2, 'Max Available', fontsize=10, color='green', ha='center')
ax.grid(True, alpha=0.3)

# Expected covers (business volume)
ax = axes[0, 1]
colors = ['red' if covers > 100 else 'orange' if covers > 60 else 'green'
          for covers in shifts['Expected_Covers']]
bars = ax.bar(shifts['Shift_ID'], shifts['Expected_Covers'], color=colors,
              alpha=0.7)
ax.set_xlabel('Shift')
ax.set_ylabel('Expected Covers (Guests)')
ax.set_title('Business Volume by Shift')
ax.grid(True, alpha=0.3)

# Add value labels
for bar, val in zip(bars, shifts['Expected_Covers']):
    ax.text(bar.get_x() + bar.get_width()/2, bar.get_height() + 2,
            str(val), ha='center', va='bottom')

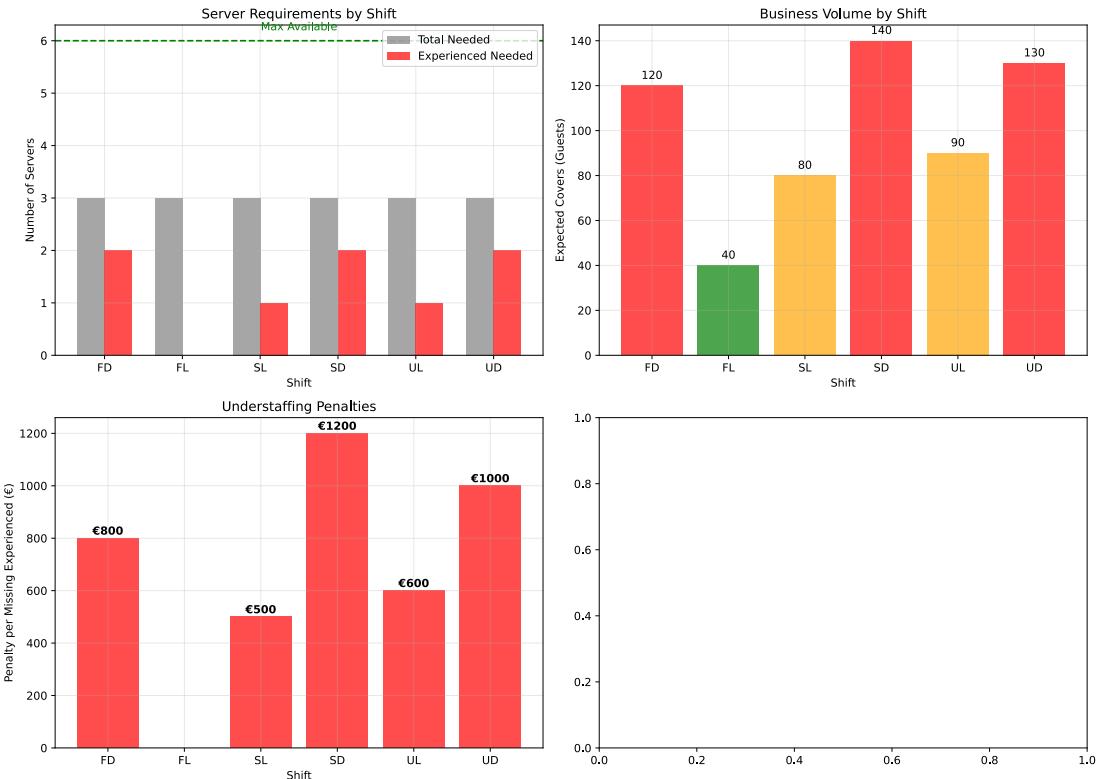
# Penalty structure
ax = axes[1, 0]
penalties = shifts['Penalty_Per_Missing'].values
bars = ax.bar(shifts['Shift_ID'], penalties, color=['red' if p > 0 else
                                                       'green' for p in penalties], alpha=0.7)
ax.set_xlabel('Shift')
ax.set_ylabel('Penalty per Missing Experienced (€)')
ax.set_title('Understaffing Penalties')
ax.grid(True, alpha=0.3)
```

```

# Add annotations
for bar, val in zip(bars, penalties):
    if val > 0:
        ax.text(bar.get_x() + bar.get_width()/2, bar.get_height() + 5,
                f'€{val}', ha='center', va='bottom', fontweight='bold')

plt.tight_layout()
plt.show()

```



## Helper Functions

```

def calculate_schedule_cost(schedule: Dict[str, List[str]],
                           servers_df: pd.DataFrame,
                           shifts_df: pd.DataFrame) -> Tuple[float, Dict]:
    """
    Calculate total cost of a schedule including labor, penalties, and
    preference scores.

    Returns:
        total_cost: Total cost in euros
        cost_breakdown: Dictionary with detailed cost breakdown
    """
    labor_cost = 0
    penalty_cost = 0
    preference_penalty = 0
    availabilityViolation_penalty = 0
    violations = []

```

```

preference_score = 0
availability_violations = 0

for shift_idx, shift_row in shifts_df.iterrows():
    shift_id = shift_row['Shift_ID']

    if shift_id not in schedule:
        continue

    assigned_servers = schedule[shift_id]

    # Calculate labor cost for this shift
    for server_id in assigned_servers:
        server = servers_df[servers_df['Server_ID'] == server_id].iloc[0]
        labor_cost += server['Hourly_Rate'] * shift_row['Hours']

    # Check availability constraints
    server_pref = pref_matrix.loc[server_id, shift_id]

    if server_pref == 0:
        # CRITICAL: Cannot assign unavailable servers!
        # Massive penalty to make this worse
        availabilityViolation_penalty += 10000
        availability_violations += 1
    else:
        # Penalty for low preferences (encourage happy staff)
        # Scale: 1 (worst) = €180 penalty, 10 (best) = €0 penalty
        preference_penalty += (10 - server_pref) * 20
        preference_score += server_pref

    # Check experienced server requirement
    experienced_count = sum(1 for sid in assigned_servers
                            if servers_df[servers_df['Server_ID'] == sid].iloc[0]['Type'] == 'Experienced')

    shortage = max(0, shift_row['Min_Experienced'] - experienced_count)
    if shortage > 0:
        penalty = shortage * shift_row['Penalty_Per_Missing']
        penalty_cost += penalty
        violations.append({
            'shift': shift_row['Shift_Name'],
            'needed': shift_row['Min_Experienced'],
            'assigned': experienced_count,
            'shortage': shortage,
            'penalty': penalty
        })

total_cost = labor_cost + penalty_cost + preference_penalty +
availabilityViolation_penalty

cost_breakdown = {
    'labor_cost': labor_cost,
    'penalty_cost': penalty_cost,
}

```

```

'preference_penalty': preference_penalty,
'availabilityViolation_penalty': availabilityViolation_penalty,
'availabilityViolations': availabilityViolations,
'total_cost': total_cost,
'violations': violations,
'average_preference': preference_score / (18 -
availabilityViolations) if (18 - availabilityViolations) > 0 else 0
}

return total_cost, cost_breakdown

def validate_schedule(schedule: Dict[str, List[str]],
                     servers_df: pd.DataFrame,
                     shifts_df: pd.DataFrame) -> Tuple[bool, List[str]]:
"""
Validate that a schedule meets all hard constraints.

Returns:
    is_valid: Boolean indicating if schedule is valid
    errors: List of constraint violations
"""
errors = []

# Check each shift has exactly 3 servers
for shift_row in shifts_df.itertuples():
    if shift_row.Shift_ID not in schedule:
        errors.append(f"Shift {shift_row.Shift_Name} has no
assignment")
    elif len(schedule[shift_row.Shift_ID]) !=
shift_row.Required_Servers:
        errors.append(f"Shift {shift_row.Shift_Name} has
{len(schedule[shift_row.Shift_ID])} servers, needs
{shift_row.Required_Servers}")

# Check each server works exactly once
all_assignments = []
for shift_servers in schedule.values():
    all_assignments.extend(shift_servers)

server_counts = pd.Series(all_assignments).value_counts()

# Check no duplicates
for server_id, count in server_counts.items():
    if count > 1:
        errors.append(f"Server {server_id} assigned {count} times
(should be 1)")

# Check all servers are assigned
all_server_ids = set(servers_df['Server_ID'])
assigned_ids = set(all_assignments)

if len(assigned_ids) != len(all_server_ids):
    missing = all_server_ids - assigned_ids
    if missing:

```

```

        errors.append(f"Servers not assigned: {', '.join(missing)}")

    # Check availability constraints (preference = 0 means cannot work)
    for shift_id, assigned_servers in schedule.items():
        for server_id in assigned_servers:
            pref = pref_matrix.loc[server_id, shift_id]
            if pref == 0:
                shift_name = shifts_df[shifts_df['Shift_ID'] == shift_id].iloc[0]['Shift_Name']
                errors.append(f"AVAILABILITY VIOLATION: {server_id} assigned to {shift_name} but is unavailable (preference=0)")

    is_valid = len(errors) == 0
    return is_valid, errors

def visualize_schedule(schedule: Dict[str, List[str]],
                      servers_df: pd.DataFrame,
                      shifts_df: pd.DataFrame,
                      cost_breakdown: Dict):
    """Create a visual representation of the schedule."""

    fig, axes = plt.subplots(2, 2, figsize=(14, 10))

    # 1. Schedule Grid
    ax = axes[0, 0]

    # Create schedule matrix
    schedule_matrix = np.zeros((len(servers_df), len(shifts_df)))

    for shift_idx, shift_row in shifts_df.iterrows():
        shift_id = shift_row['Shift_ID']
        if shift_id in schedule:
            for server_id in schedule[shift_id]:
                server_idx = servers_df[servers_df['Server_ID'] == server_id].index[0]
                schedule_matrix[server_idx, shift_idx] = 1

    # Color based on server type
    colors = []
    for server in servers_df.itertuples():
        if server.Type == 'Experienced':
            colors.append('red')
        else:
            colors.append('blue')

    # Plot
    im = ax.imshow(schedule_matrix, cmap='YlOrRd', aspect='auto')
    ax.set_xticks(range(len(shifts_df)))
    ax.set_xticklabels(shifts_df['Shift_ID'])
    ax.set_yticks(range(len(servers_df)))
    ax.set_yticklabels([f"{row.Server_ID} ({row.Type[0]})" for row in servers_df.itertuples()],
                      fontsize=8)
    ax.set_xlabel('Shift')

```

```

ax.set_ylabel('Server')
ax.set_title('Schedule Assignment Matrix')

# Add grid
for i in range(len(servers_df) + 1):
    ax.axhline(i - 0.5, color='gray', linewidth=0.5)
for i in range(len(shifts_df) + 1):
    ax.axvline(i - 0.5, color='gray', linewidth=0.5)

# 2. Cost Breakdown
ax = axes[0, 1]
costs = {
    'Labor': cost_breakdown['labor_cost'],
    'Penalties': cost_breakdown['penalty_cost']
}
bars = ax.bar(costs.keys(), costs.values(), color=['green', 'red'],
alpha=0.7)
ax.set_ylabel('Cost (€)')
ax.set_title(f"Total Cost: €{cost_breakdown['total_cost']:.2f}")

for bar, val in zip(bars, costs.values()):
    ax.text(bar.get_x() + bar.get_width()/2, bar.get_height() + 10,
            f'€{val:.0f}', ha='center', va='bottom', fontweight='bold')

# 3. Violations
ax = axes[1, 0]
if cost_breakdown['violations']:
    violations_df = pd.DataFrame(cost_breakdown['violations'])
    x = range(len(violations_df))
    ax.bar(x, violations_df['shortage'], color='red', alpha=0.7)
    ax.set_xticks(x)
    ax.set_xticklabels(violations_df['shift'], rotation=45, ha='right')
    ax.set_xlabel('Missing Experienced Servers')
    ax.set_title('Understaffing by Shift')
    ax.grid(True, alpha=0.3)
else:
    ax.text(0.5, 0.5, 'No Violations!\n(All requirements met)',
            ha='center', va='center', fontsize=14, color='green')
    ax.set_title('Violations')
ax.axis('on')

# 4. Server Type Distribution
ax = axes[1, 1]
shift_composition = []
for shift_id in shifts_df['Shift_ID']:
    if shift_id in schedule:
        exp_count = sum(1 for sid in schedule[shift_id]
                        if servers_df[servers_df['Server_ID'] == sid].iloc[0]['Type'] == 'Experienced')
        jun_count = len(schedule[shift_id]) - exp_count
        shift_composition.append({'Shift': shift_id, 'Experienced': exp_count, 'Junior': jun_count})

if shift_composition:

```

```

comp_df = pd.DataFrame(shift_composition)
x = range(len(comp_df))
width = 0.35
ax.bar([i - width/2 for i in x], comp_df['Experienced'], width,
       label='Experienced', color='red', alpha=0.7)
ax.bar([i + width/2 for i in x], comp_df['Junior'], width,
       label='Junior', color='blue', alpha=0.7)
ax.set_xticks(x)
ax.set_xticklabels(comp_df['Shift'])
ax.set_ylabel('Number of Servers')
ax.set_title('Staff Composition by Shift')
ax.legend()
ax.grid(True, alpha=0.3)

plt.tight_layout()
plt.show()

# Test with a random valid schedule
def create_random_schedule(servers_df, shifts_df):
    """Create a random valid schedule for testing."""
    schedule = {}
    available_servers = list(servers_df['Server_ID'])
    random.shuffle(available_servers)

    server_idx = 0
    for shift_row in shifts_df.itertuples():
        schedule[shift_row.Shift_ID] =
            available_servers[server_idx:server_idx + shift_row.Required_Servers]
        server_idx += shift_row.Required_Servers

    return schedule

# Test the helper functions
test_schedule = create_random_schedule(servers, shifts)
test_cost, test_breakdown = calculate_schedule_cost(test_schedule, servers,
shifts)
is_valid, errors = validate_schedule(test_schedule, servers, shifts)

print(f"\nRANDOM SCHEDULE TEST:")
print(f"Valid: {is_valid}")
print(f"Total Cost: €{test_cost:.2f}")
print(f" - Labor: €{test_breakdown['labor_cost']:.2f}")
print(f" - Penalties: €{test_breakdown['penalty_cost']:.2f}")
if test_breakdown['violations']:
    print(f"Violations: {len(test_breakdown['violations'])} shifts
understaffed")

```

RANDOM SCHEDULE TEST:  
Valid: False  
Total Cost: €58140.00  
- Labor: €3400.00

```
- Penalties: €3800.00  
Violations: 3 shifts understaffed
```

## Your Task

Design the optimal server schedule that minimizes total cost while managing multiple complex constraints.

## The Challenge

This is NOT a simple assignment problem! You must balance:

- Varying shift lengths (4-6 hours) that affect labor costs differently
- Server preferences (1-10) where lower values mean unhappy staff and quality issues
- Strategic penalty decisions - penalties range from €0 to €1200
- Three cost components: labor + experience penalties + preference penalties

## Approach Options

You can use ANY approach you prefer:

1. Smart Greedy - Consider preferences AND penalties in your rules
2. Local Search - Start with valid schedule (respecting 0 preferences), improve with constraint-aware swaps
3. Metaheuristics - Use AI to implement SA, GA, etc. that handle hard constraints
4. Hybrid - Combine approaches (e.g., greedy for feasibility, then SA for optimization)
5. Creative - Surprise me with novel constraint-handling techniques!

Remember: Unhappy staff (low preferences) lead to quality issues and small penalties that add up!

## Your Solution

Implement your solution below. You can use greedy, metaheuristic, or hybrid approaches.

### AI-Assisted Metaheuristic Template

```
# Template for using AI to implement metaheuristics
"""
You are an expert in constraint-handling techniques for metaheuristic problems.

I need to solve a complex [PROBLEM NAME] using [ALGORITHM NAME].  

Problem details: [PROVIDE ALL PROBLEM DETAILS HERE]  

Constraints: [PROVIDE ALL CONSTRAINTS YOU NEED TO MEET HERE]  

Objective: [PROVIDE THE OBJECTIVE AND ALL POSSIBLE PENALTIES]
```

Data: [PROVIDE DATA OR SAVE DATA AS CSV AND LINK FILES]

Please assist me and provide:

1. Solution representation
2. Neighborhood/move function that considers [E.G. INFEASIBILITY, ETC.]
3. Cost calculation including all components
4. Main algorithm loop with optimization
5. Parameter recommendations for this specific problem

Plan first and discuss all open questions with me before the implementation.

"""

```
'\nYou are an expert in constraint-handling techniques for metaheuristic problems.\n\nI need to solve a complex [PROBLEM NAME] using [ALGORITHM NAME].\n\nProblem details: [PROVIDE ALL PROBLEM DETAILS HERE]\n\nConstraints: [PROVIDE ALL CONSTRAINTS YOU NEED TO MEET HERE]\n\nObjective: [PROVIDE THE OBJECTIVE AND ALL POSSIBLE PENALTIES]\n\nData: [PROVIDE DATA OR SAVE DATA AS CSV AND LINK FILES]\n\nPlease assist me and provide:\n1. Solution representation\n2. Neighborhood/move function that considers [E.G. INFEASIBILITY, ETC.]\n3. Cost calculation including all components\n4. Main algorithm loop with optimization\n5. Parameter recommendations for this specific problem\n\nPlan first and discuss all open questions with me before the implementation.\n'
```

## Step 1: Implementation

Implement your solution below:

```
# YOUR SOLUTION CODE HERE

def my_scheduling_algorithm(servers_df, shifts_df):
    """
    Your scheduling algorithm implementation.
    Can be greedy, metaheuristic, or hybrid.
    """
    # YOUR CODE HERE

    # ... your implementation ...

    # For now, returning a random solution as placeholder
    return create_random_schedule(servers_df, shifts_df)

# Run your solution
my_schedule = my_scheduling_algorithm(servers, shifts)
my_cost, my_breakdown = calculate_schedule_cost(my_schedule, servers,
shifts)

# Validate
is_valid, validation_errors = validate_schedule(my_schedule, servers,
shifts)
```

```

print("MY SOLUTION:")
print("=" * 60)
if not is_valid:
    print("INVALID SCHEDULE:")
    for error in validation_errors:
        print(f" - {error}")
else:
    print("Valid Schedule")

print(f"\nTotal Cost: €{my_cost:.2f}")
print(f" Labor: €{my_breakdown['labor_cost']:.2f}")
print(f" Penalties: €{my_breakdown['penalty_cost']:.2f}")

print(f"\nImprovement over random: {(test_cost - my_cost)/test_cost*100:.1f}%")

# Visualize your solution
if is_valid:
    visualize_schedule(my_schedule, servers, shifts, my_breakdown)

```

```

MY SOLUTION:
=====
INVALID SCHEDULE:
- AVAILABILITY VIOLATION: E03 assigned to Friday Dinner but is
unavailable (preference=0)
- AVAILABILITY VIOLATION: E06 assigned to Friday Late but is unavailable
(preference=0)
- AVAILABILITY VIOLATION: E01 assigned to Sunday Lunch but is unavailable
(preference=0)
- AVAILABILITY VIOLATION: J08 assigned to Sunday Dinner but is
unavailable (preference=0)

Total Cost: €47220.00
Labor: €3600.00
Penalties: €2700.00

Improvement over random: 18.8%

```

## Step 2: Create Your Submission

Prepare a one-slide presentation (PDF) containing:

- Your Best Schedule: Total cost prominently displayed (labor + penalties + preferences)
- Approach: Which solution generation method(s) did you use?
- Cost Breakdown: Visualization showing the three cost components (labor, experience penalties, preference penalties)
- Shift Assignments: Table showing each shift with experienced vs junior server counts
- Strategy Justification: 2-3 sentences explaining why your schedule is optimal

## Tips for Success

1. Start simple: Try random generation or greedy assignment first to understand the solution space
2. Check feasibility: Always verify availability constraints ( $\text{preference} \neq 0$ ) before assigning
3. Preferences matter: Low preference scores create unhappy staff and add €180+ in penalties
4. Strategic penalties: Some shifts have €0 penalties (Friday Late), use these wisely
5. Balance all three costs: Labor, experience penalties, AND preference penalties all matter

## Common Pitfalls to Avoid

- Violating availability constraints: Assigning servers to shifts where  $\text{preference} = 0$  triggers massive penalties
- Ignoring preferences: Low-preference assignments (1-3) add up quickly in costs
- Missing the shortage: You need 8 experienced servers but only have 6, plan which penalties to accept
- Incorrect cost calculation: Must include all three components: labor + experience penalties + preference penalties

## Final Checklist

Before submitting your solution, verify:

- Schedule assigns each server exactly once
- Each shift has exactly 3 servers
- No availability violations ( $\text{preference} = 0$  assignments)
- Cost calculation includes all three components
- Justification explains your strategic penalty decisions (2-3 sentences)
- One-slide presentation ready with cost breakdown and shift assignments

## Good Luck!

May the best schedule win!

## Bibliography